Effects of Meniscus and Defect Size, Location and Orientation on Rim Stress and Subchondral Bone Contact of Focal Cartilage Defects of the Knee

Undergraduate Research Thesis

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by

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Abstract

Osteoarthritis in the knee is a painful condition which affects many adults in their lifetime. As a result of physical activity or trauma, it is common for people to develop holes in their cartilage called defects. If left untreated, defects may progress to osteoarthritis. Two factors believed to directly contribute to defect progression are the development of stress gradients around the defect's perimeter and the contact that the bone within the defect area makes with the opposing joint surface. These factors are influenced by a variety of characteristics of the knee and the defect; however the surgical algorithm for treating these defects only takes defect size into account. This project investigates the effects of meniscal presence and amount of loading seen at the defect, and the defect size, location, and orientation on subchondral bone contact and rim stresses that develop around circle and oval-shaped defects in porcine knees. 40 knees with circle-shaped defects and 80 with oval-shaped defects were tested. Knees were mounted in an Instron compression fixture and cartilage defects were created at the point of peak pressure. Between each loading sequence, defect size was increased concentrically. Tekscan pressure sensors were used to obtain pressure distributions of each compression, which were used to quantify rim stress and subchondral bone contact. General linear models were analyzed in data subsets of circle defects, oval defects, and a combined dimensional analysis. Results indicated that all believed factors of defect progression affected both rim stress and subchondral bone contact as either a single factor or interaction. For circle and oval-shaped defects, defect size was not significant as a single factor affecting rim stress; these findings strongly suggest that defect size is not the only factor affecting defect progression. This study suggests the need for a new treatment algorithm which takes into account the collective influences of the physical factors of the knee and defect in order to provide more patient-specific treatment options.

Acknowledgements

Many people contributed to the success of this project. First, I would like to thank my advisor, Dr. Robert Siston, for mentoring me throughout my entire undergraduate career. He has pushed me to succeed academically while providing me with numerous opportunities to gain research experience. When I first started working with him four years ago, I would never have imagined that I would have worked as hard and accomplished as much as I have under his guidance. Without his support and encouragement, this thesis would not have been possible, and I am deeply grateful.

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Chapter 1: Introduction

Articular cartilage is the smooth, white tissue that covers the ends of the bones inside a joint. Healthy cartilage facilitates movement in the joints by providing a low-friction surface which is capable of bearing weight through the necessary range of motion [1]. However, articular cartilage can become damaged by trauma or normal wear and tear, and this severely impacts the functionality of the cartilage. This deterioration of cartilage can also be very painful. The cartilage cannot repair itself, and this condition will often lead to osteoarthritis if left untreated [2].

Figure 1: The Knee
www.yourdictionary.com

The menisci in the knee consist of two C-shaped fibrocartilaginous structures that act as a shock absorber between the femoral condyles and tibia. It helps to cushion and stabilize the joint while reducing contact stresses, so an injury or tear to the meniscus can severely limit knee joint function [3]. One solution to a meniscus injury is a procedure called a meniscectomy, in which either one or both menisci are surgically removed in order to relieve pain and restore short-term joint function. However, long term results of this procedure are unfavorable; many studies have linked meniscectomies to higher contact stresses in the joint which may contribute to cartilage degeneration [4].

Osteoarthritis is a chronic and painful condition characterized by the degeneration of cartilage. Mechanical stress on the weight-bearing joints in the body contributes to a loss of cartilage volume, which makes everyday activities such as walking, running, and climbing stairs very difficult [5]. Those with osteoarthritis often experience a decreased range of motion, as well as swelling, stiffness, and pain in the joint [1]. An estimated 27 million Americans are currently living with osteoarthritis and it typically affects people of an older age [6]. By the year 2020, an estimated 60 million people in the United States are expected to be affected by osteoarthritis [7].

Figure 2: Osteoarthritis of the Knee
www.interactive-biology.com

Roughly two million people every year are diagnosed with cartilage defects, which can be thought of as “potholes” in the articular cartilage of the knee [6, 8]. Cartilage defects are also painful and debilitating; however unlike osteoarthritis, they are not age-dependent [6]. These defects can be due to either trauma or cartilage degeneration and may grow in size over time [9]. Cartilage defects in otherwise healthy individuals are very common. In particular, athletes experience defects at higher rates than the general population [10]. An estimated 39% of all athletes and 59% of NBA players and long distance runners have a cartilage defect. While the mechanics of cartilage defects are not entirely understood, there is evidence which suggests that they may progress to osteoarthritis if left untreated [11].

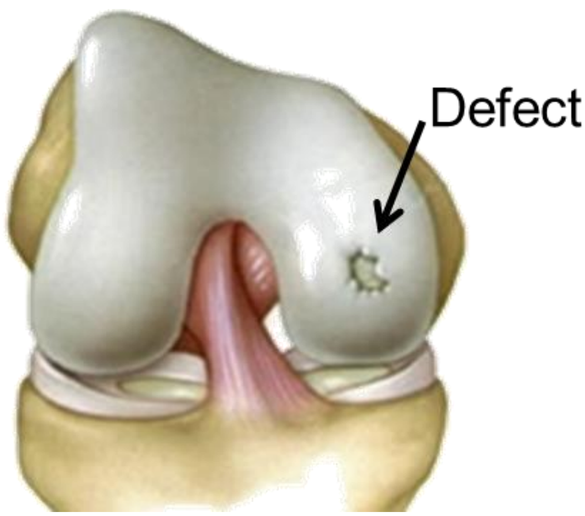

Figure 3: Cartilage defect on knee joint
www.vangsnessmd.com/orthoproc_cartilage.htm

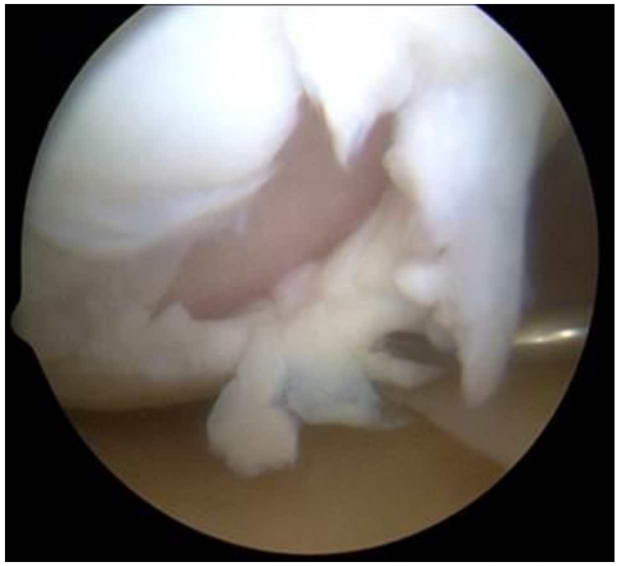

Figure 4: Cartilage defect in vivo
www.howardluksmd.com

There are several options of surgical procedures for those with cartilage defects looking to improve the health of their cartilage and overall quality of life. Typically, defects smaller than 2-3 cm^2 will be treated differently than defects of a larger size [9, 12, 13]. Microfracture (MFX) is a marrow-stimulation technique which is common procedure for smaller defects [13]. Another common procedure for smaller defects is osteochondral autograft transplantation (OATS), which involves drilling into the damaged cartilage area and inserting a cartilage plug harvested from a non-weight bearing area of the patient. Defects larger than the threshold size are often treated with osteochondral allograft transplantation (OCA), which is the insertion of a large, cadaveric osteochondral graft [7, 13]. Large defects are also commonly treated by autologous chondrocyte implementation (ACI), which is a multi-step process where cartilage is harvested from a non-weight bearing area on the patient, and replaced after being isolated and grown for several weeks in tissue culture [13].

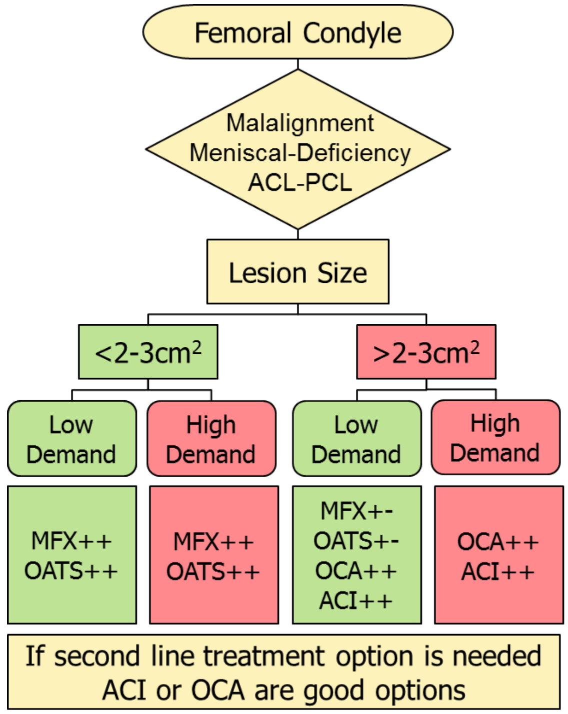

Figure 5: Current treatment algorithm for cartilage defects on the femoral condyle of the knee. A threshold size of 2-3 cm² is the only characteristic of the defect taken into account in determining a patient's treatment options [9].

Cartilage defects are thought to enlarge in size and progress as the result of two mechanisms: the development of rim stress and subchondral bone contact [14-17]. Rim stress is characterized by the appearance of a stress gradient on the cartilage surrounding the area of the defect. High contact stress gradients at the rim contribute to a poor healing environment in this area, allowing the defect to expand outward [16]. Subchondral bone contact is defined as the event in which the femoral bone beneath the articular cartilage makes contact with the opposing surface of the tibia in the absence of its protective cartilage covering. This direct application of pressure hardens the subchondral bone and causes the cartilage to detach at its base, furthering the size of the defect [7, 17].

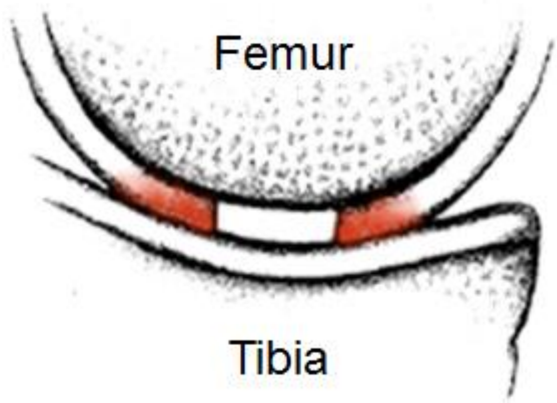

Figure 6: Cartilage defect progression mechanism: rim stress
Minas, T. and Nehrer, S., 1997. Orthopedics 20, 525-38.

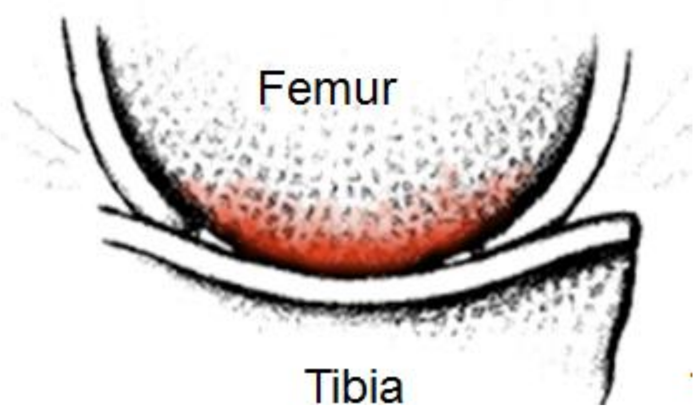

Figure 7: Cartilage defect progression mechanism: subchondral bone contact
Minas, T. and Nehrer, S., 1997. Orthopedics 20, 525-38.

The progression of the defect growth and subsequent development of osteoarthritis are considered to be dependent on multiple factors. Characteristics of the patient's knee, including bone geometry and a history of anterior cruciate ligament or meniscal tears, are believed to affect the growth of cartilage defects [5, 15]. Additionally, physical factors of the defect itself, including size, depth, shape, orientation, and location, are also believed to contribute to the development and progression of defects on the knee [11]. These features can vary significantly from person to person; for example, a defect in a 300 pound football player's knee logically should not progress the same way as a defect in a 100 pound gymnast's knee.

However, the current clinical treatment options for cartilage defects are largely determined by a predetermined threshold defect size [5]. More than 500,000 defect surgeries are performed every year in the U.S., and the majority of these are repeat procedures [18]. This suggests that the current model for determining cartilage defect treatment options is not optimal. In order to optimize the defect treatment algorithm, it is necessary to understand the full range of factors affecting the development of rim stress and subchondral bone contact. Previous studies have been successful in demonstrating that factors other than defect size play some role in defect progression. For example, Papaioannou demonstrated the significance of defect location on peak rim pressure in addition to defect size, while Peňa showed the effects of defect size, location, and the presence of the meniscus on rim stress in a computational study [14, 15]. Although these studies are useful in determining the flaws in the current treatment model, none of them have taken a comprehensive look at all of the believed factors of progression and analyzed them in a single study. Therefore, we are lacking information about the significance of each of the factors of defect progression and their interactions with one another in the knee.

Although previous studies have shown that defect size influences rim stress and subchondral bone contact, there are numerous studies which suggest that other factors such as shape, location, orientation, and meniscus also affect these factors leading to defect progression [12, 14-16]. However, none of these studies have combined their findings to illustrate a more comprehensive picture of how these factors may work together to influence the mechanical environment of the knee. In order to understand the full extent of the mechanisms leading to defect progression, there is a need to relate the effects of the factors of a defect (size, shape, location, and orientation) and the effects of the physical factors of the knee (presence of meniscus) to the development of subchondral bone contact and rim stresses surrounding a defect at various loads. Such information can then be used to create a more patient-specific defect treatment algorithm.

1.1 Focus of Thesis

This study analyzed the effects of defect size, shape, location, and orientation and presence of meniscus on rim stress and subchondral bone contact in porcine knees at various loads. By creating defects in the articular cartilage of the knees and generating different combinations of the factors of defect progression, this study was able to provide a deeper understanding of the collective influence of these factors on the mechanisms that are believed to be responsible for the growth of cartilage defects.

1.2 Significance of Research

Reparative surgeries for cartilage defects are very common, but the outcomes vary in success, suggesting issues with the current treatment algorithm [18]. While other studies have shown the effect of a range of physical factors of the knee and defect on rim stress and/or subchondral bone contact, no studies have evaluated all of the hypothesized factors at the same time. By analyzing the effects of defect size, location, shape, and orientation, presence of meniscus, and load on rim stress and subchondral bone contact, information about the role that each of these factors play were obtained in a single study. This experimental design allows the interactions between factors to be evaluated in addition to their direct impact in order to more fully understand the mechanical environment of a knee with cartilage defects. The results of this study can not only be used to comment on the effectiveness of the current treatment model, but also to provide information useful in creating a new treatment algorithm that takes patient-specific features into account. With a more patient-specific understanding of treatment options, cartilage defect treatment procedures may yield a higher success rate, which would improve the quality of life of those with cartilage defects.

1.4 Overview of Thesis

This thesis contains 4 chapters. Chapter 2 discusses the methodology for testing the knees. This consists of the procedure for dissecting the knees and mounting them in a compression fixture. This chapter also discusses the creation of cartilage defects of varying size, shape, location, and orientation. Lastly, this chapter includes information on using an Instron to load the knees and the methods for data collection. Chapter 3 discusses the results of the knees tested with circle defects and oval defects. This chapter also presents the results of the combination of both data sets in a dimensional analysis. Chapter 4 summarizes the findings of this thesis and proposes further steps that can be taken in this area of study.

Chapter 2: Methodology

120 fresh, healthy porcine knees were shipped from the J.H. Routh Packing Company (Sandusky, OH) weekly for this study. At the time of arrival, the knees consisted of the femur, tibia, fibula, patella, and surrounding connective tissue. The patella and fibula were then removed and in order to access the rest of the joint, each knee was trimmed of all subcutaneous tissue. The lateral collateral ligament was removed as it is attached to the fibula. Knees with visible cartilage fissuring or full-thickness defects were excluded from the study. The cruciate ligaments, the medial collateral ligament, and meniscus were all initially left intact.

Figure 8: Knee before preparation. The femur, tibia, fibula, patella, ligaments, meniscus, and connective tissues are still intact.

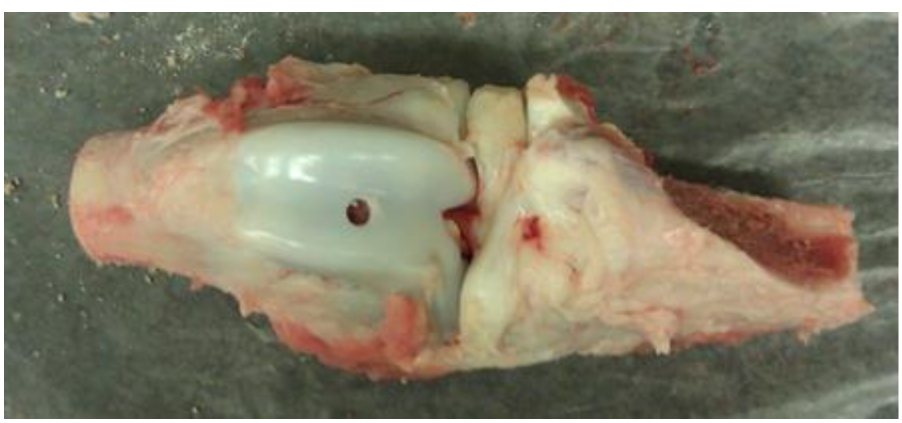

Figure 9: Knee after preparation. The patella, fibula, lateral collateral ligament and connective tissues have been removed. The femur and tibia have been trimmed to fit the compression fixture. The meniscus is still intact.

In order to mount the knee in the compression fixture in the Instron machine, both the femur and the tibia were cut with a handsaw to fit the length of the fixture plates (approximately 4 inches). The knee was then secured in the fixture with drywall screws, starting with the tibia and then the femur to ensure full extension of the joint. At this point, the entire meniscus was removed if specified. The medial collateral ligament was removed for all knees so that Tekscan model 4000 electronic pressure sensors could easily be inserted into the joint between both of the femoral condyles and either the meniscus or the tibial articular surface.

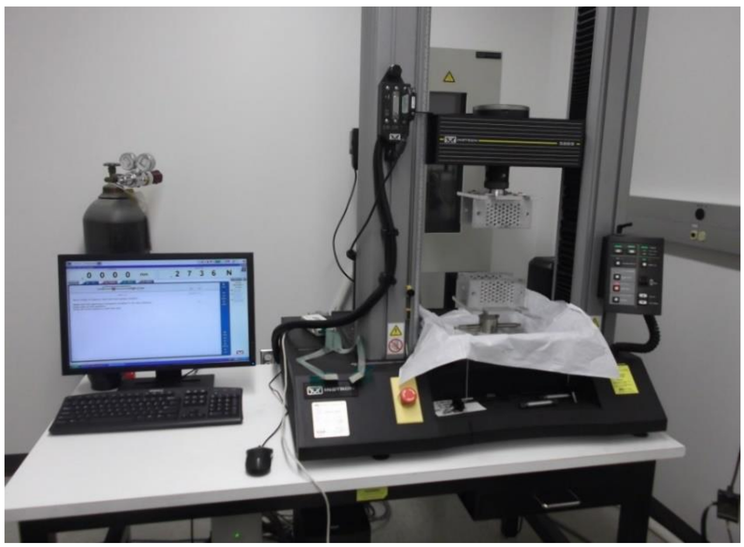

Figure 10: Instron setup before loading the knee into the compression fixture.

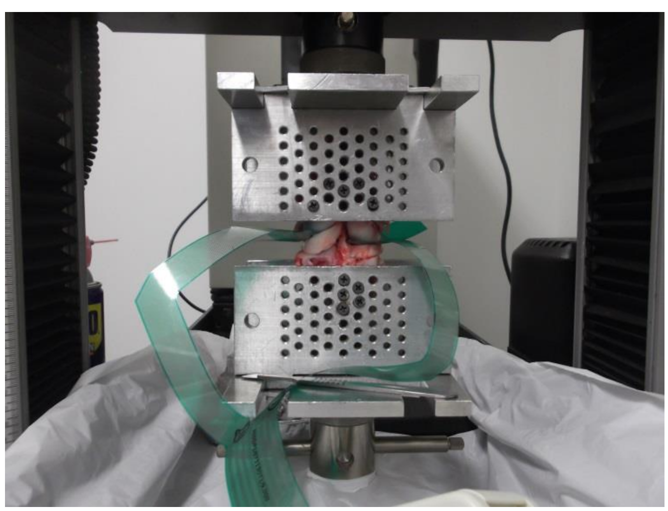

Figure 11: After knee is loaded into the compression fixture. Tekscan sensors have been inserted into the joint between the femoral condyles and the meniscus or tibial plateau.

Once both sides of the Tekscan sensor were placed in the joint, the sensor was calibrated. A two-point calibration was performed where the knee was loaded to approximately 30% and 90% of the total load specified for that sample. Sensors were typically recalibrated every 2 knees tested or as needed to ensure accuracy. Once calibrated, each knee was loaded with intact cartilage in order to locate the point of peak pressure on each condyle. I-scan software was used with the sensors to create a real-time pressure distribution for each compression. The sensors were then removed from the joint and the femoral component of the fixture was removed from the Instron and flexed to expose the articular surface of the condyles.

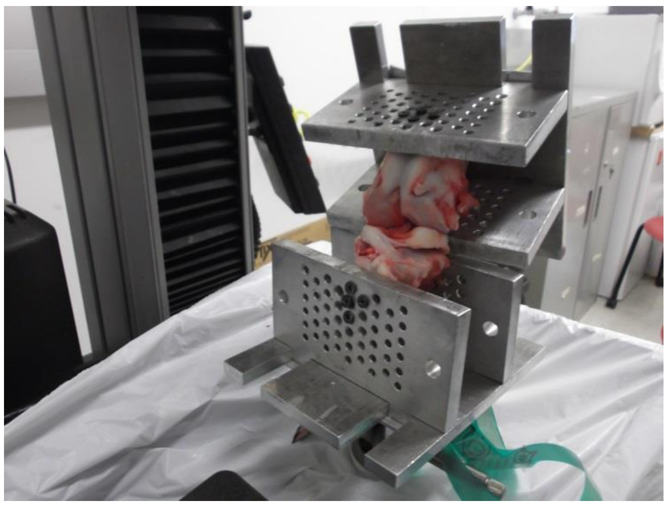

Figure 12: The knee is flexed to expose the femoral cartilage.

For circle-shaped defects, circular mechanical coring punches were used to create a series of full-thickness defects on both condyles at the point of peak pressure. The testing conditions for circular defects are summarized below.

Number of Knees	Load (N)	Meniscus
10	445	Yes
10	445	No
10	900	Yes
10	900	No

Table 1: Experiment design for knees with circle-shaped defects. An equal number of knees were tested in each subcategory of various load and meniscus. A total of 40 knees were tested.

After creating a defect, the femoral component was placed back in the Instron and the knee was loaded at a rate of 3mm/min and held for 5 seconds at the peak load. The pressure distribution was recorded for each loading sequence. Between each compression, the defects were concentrically increased starting at a coring punch diameter of 5 mm followed by 6, 8, 10 and 12.5 mm.

For oval-shaped defects, the same mechanical coring punches were used to create full-thickness defects. The testing conditions for oval-shaped defects are summarized below.

Number of Knees	Load (N)	Meniscus	Number of medial-lateral defects	Number of anterior-posterior defects
20	445	Yes	20	20
20	445	No	20	20
20	900	Yes	20	20
20	900	No	20	20

Table 2: Experiment design for knees with oval-shaped defects. An equal number of knees were tested for each subcategory of various load, meniscus, medial defect orientation, and lateral defect orientation. A total of 80 knees were tested.

The same method of removing the femoral component of the fixture was used to expose the cartilage; however, two circular defects were created side-by-side at the point of peak pressure instead of one. A scalpel was used to carefully shape the rest of the oval. Within each variation of meniscus and load, random combinations of medial-lateral (ML) oriented defects and anterior-posterior (AP) oriented defects were loaded at the same time on both condyles. Between each compression, defects were once again enlarged concentrically with punches of 5, 6, 8, 10, and 12.5 mm diameters. Again, the knees were removed from the fixture at completion and frozen until bone geometries could be analyzed.

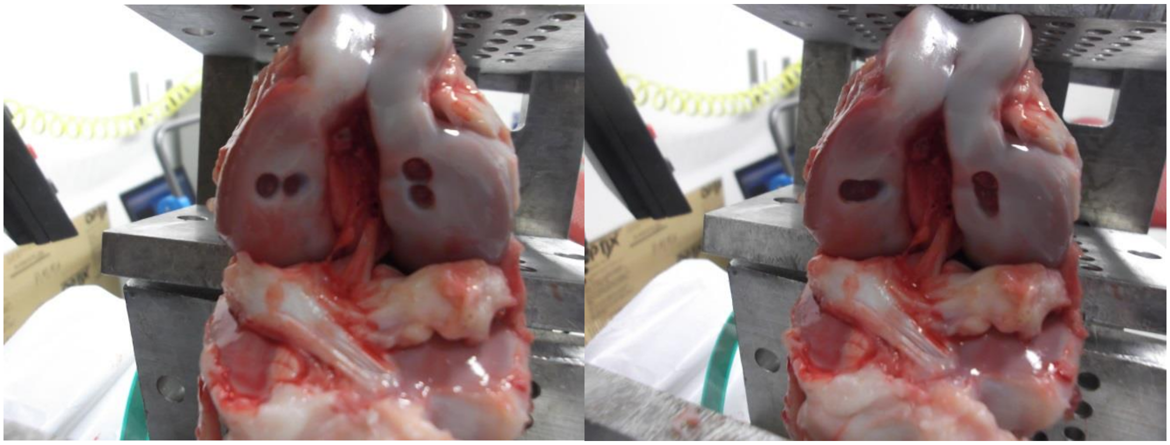

Figure 13: Two side-by-side circular defects on each condyle before and after being shaped into an oval.

From the pressure distribution videos obtained using I-scan software, we were able to find the peak circumferential rim stress around the defect. A Matlab script written by Pete Brockmeier, a previous graduate student in the lab, was used to determine the area of any subchondral bone contact present within any of the surgically created defects for all knees [19]. Subchondral bone contact is defined as any nonzero pressure that appears within the area of the defect, and still-frame images from the pressure distributions at the instance of peak pressure for each test will be used to analyze the amount of contact.

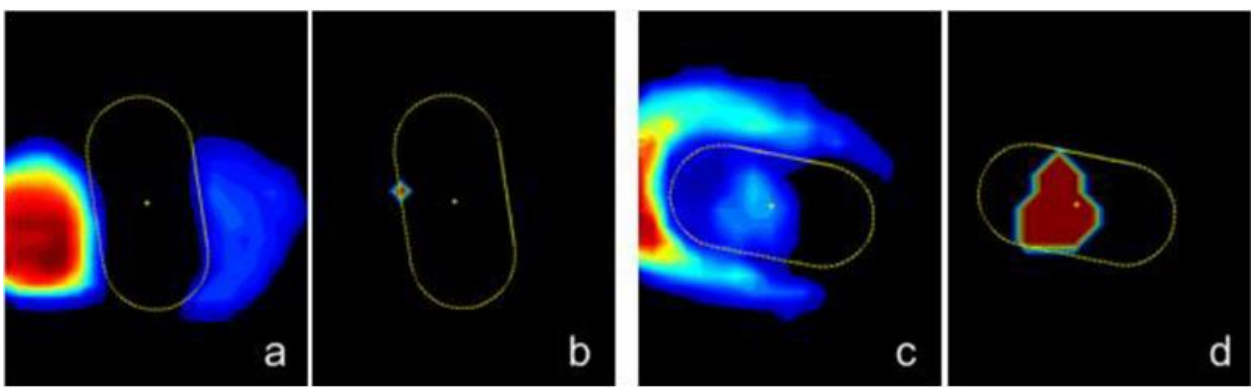

Figure 14: Screenshot of a pressure distribution being analyzed in Matlab to determine the area of subchondral bone contact of an oval-shaped defect. Images by Pete Brockmeier.

Chapter 3: Results

Following data collection, the testing conditions and resulting data were organized in Minitab. Circle defect statistical analysis consisted of four independent variables (load, presence of menisci, condyle, and defect size) and the effects of these factors on rim stress and subchondral bone contact development. Oval defect analysis investigated the effects of five independent variables (load, presence of menisci, condyle, defect size, and orientation) on rim stress and SBC. Circle and oval defect data were combined into a singular data set with load, presence of menisci, condyle, medial-lateral orientation, and anterior-posterior orientation as factors affecting rim stress and SBC. General linear models of each subset determined the statistical significance of single factors and two-factor interactions as they affect each of the two mechanisms of cartilage defect progression. Main effects and interaction factorial plots were created to further investigate how the factors contributed to rim stresses and SBC areas.

3.1 Circle Defect Analyses

3.1.1 Peak Pressure in Circular Defects

In circular defects, peak rim stress surrounding the defect was significantly higher when the joint was subjected to a higher load ($p < 0.001$), when there was no meniscus present in the joint ($p < 0.001$), and when defects occurred on the lateral femoral condyle rather than the medial condyle ($p = 0.001$). Defect size did not affect peak pressure values around the defect ($p = 0.808$). The interaction between load and meniscus significantly affected the development of rim stresses in circular defects ($p < 0.001$).

	Load	Meniscus	Condyle	Defect Size
Load	**<0.001**	X	X	X
Meniscus	**<0.001**	**<0.001**	X	X
Condyle	0.059	0.694	**0.001**	X
Defect Size	0.996	0.856	0.984	0.808

Table 3: P-values to determine significance of the individual defect factors and their interactions on rim stress in circular defects. Bolded values indicate statistical significance (significant for $p < 0.05$).

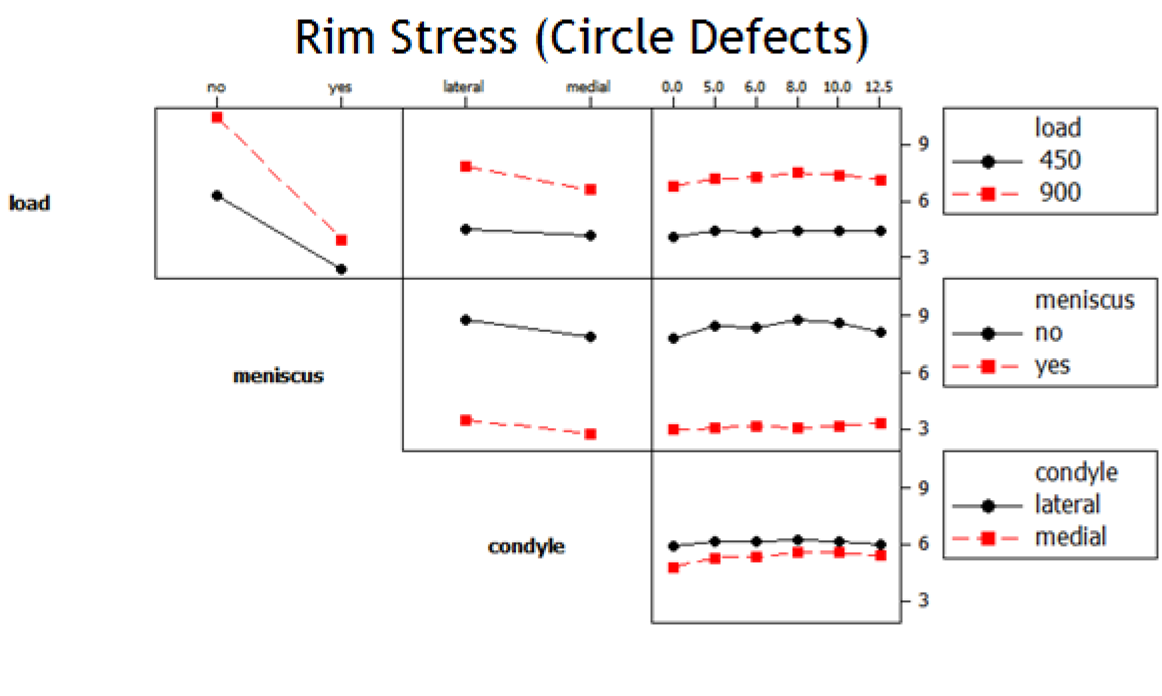

Figure 15: Factorial plots for the defect factor interactions affecting rim stress in circle defects

3.1.2 Subchondral Bone Contact in Circular Defects

For circular defects, greater areas of subchondral bone contact were seen in knees with no menisci ($p < 0.001$), knees with defects on the lateral femoral condyle ($p = 0.004$), and knees with larger defect sizes ($p < 0.001$). The size of the load applied to the joint was not statistically linked to the development of subchondral bone contact ($p = 0.702$). The interactions between condyle and presence of a meniscus ($p = 0.004$), defects size and meniscus ($p < 0.001$), and condyle and defect size ($p < 0.001$) significantly affected the development of subchondral bone contact in circle defects.

	Load	Meniscus	Condyle	Defect Size
Load	0.702	X	X	X
Meniscus	0.702	**<0.001**	X	X
Condyle	0.307	**0.004**	**0.004**	X
Defect Size	0.634	**<0.001**	**<0.001**	**<0.001**

Table 4: P-values to determine significance of the individual defect factors and their interactions on subchondral bone contact in circular defects. Bolded values indicate statistical significance (significant for $p < 0.05$).

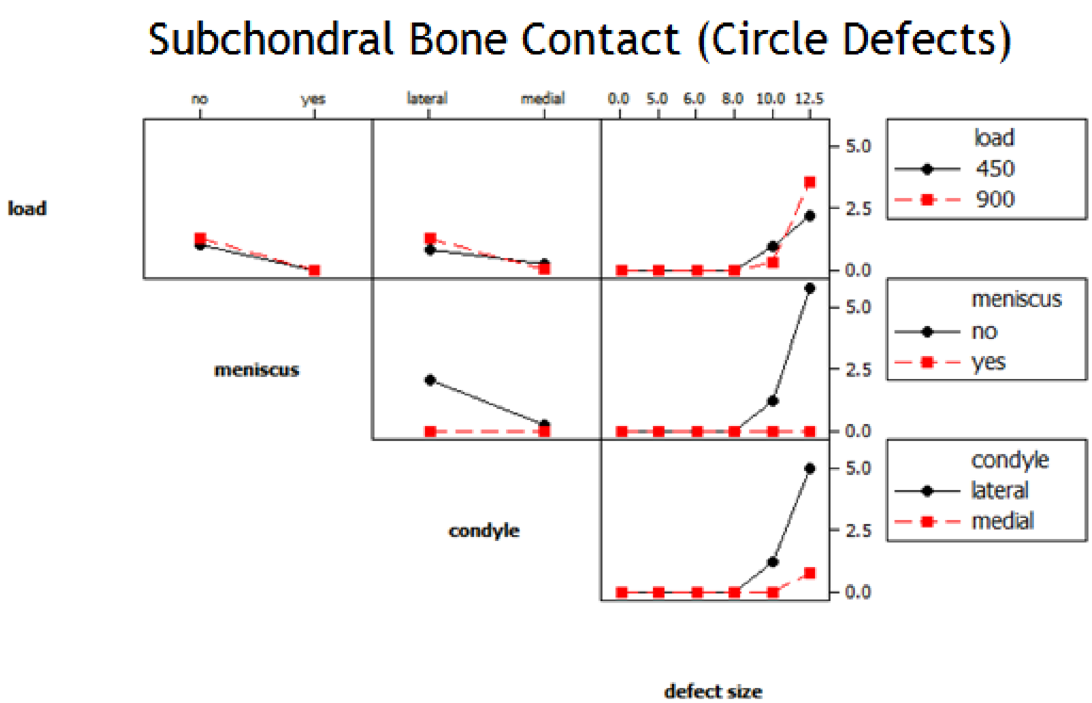

Figure 16: Factorial plots for the defect factor interactions affecting subchondral bone contact in circle defects

3.2 Oval Defect Analyses

3.2.1 Peak Pressure in Oval Defects

For oval-shaped defects, individual factors that contributed to larger peak pressures around the rim of the defect were higher loads ($p < 0.001$) and a lack of menisci ($p < 0.001$). Rim stress values were not linked to condyle ($p = 0.411$) or defect size ($p = 0.411$). Significant interactions affecting rim stress in oval defects are between load and presence of a meniscus ($p < 0.001$), defect orientation and presence of a meniscus ($p = 0.001$), and condyle and defect size ($p = 0.013$).

	Load	Meniscus	Condyle	Defect Size	Orientation
Load	**<0.001**	X	X	X	X
Meniscus	**<0.001**	**<0.001**	X	X	X
Condyle	0.968	0.082	0.411	X	X
Defect Size	0.835	0.066	**0.013**	0.411	X
Orientation	0.659	**0.001**	0.157	0.855	0.074

Table 5: P-values to determine significance of the individual defect factors and their interactions on rim stress in oval defects. Bolded values indicate statistical significance (significant for $p < 0.05$).

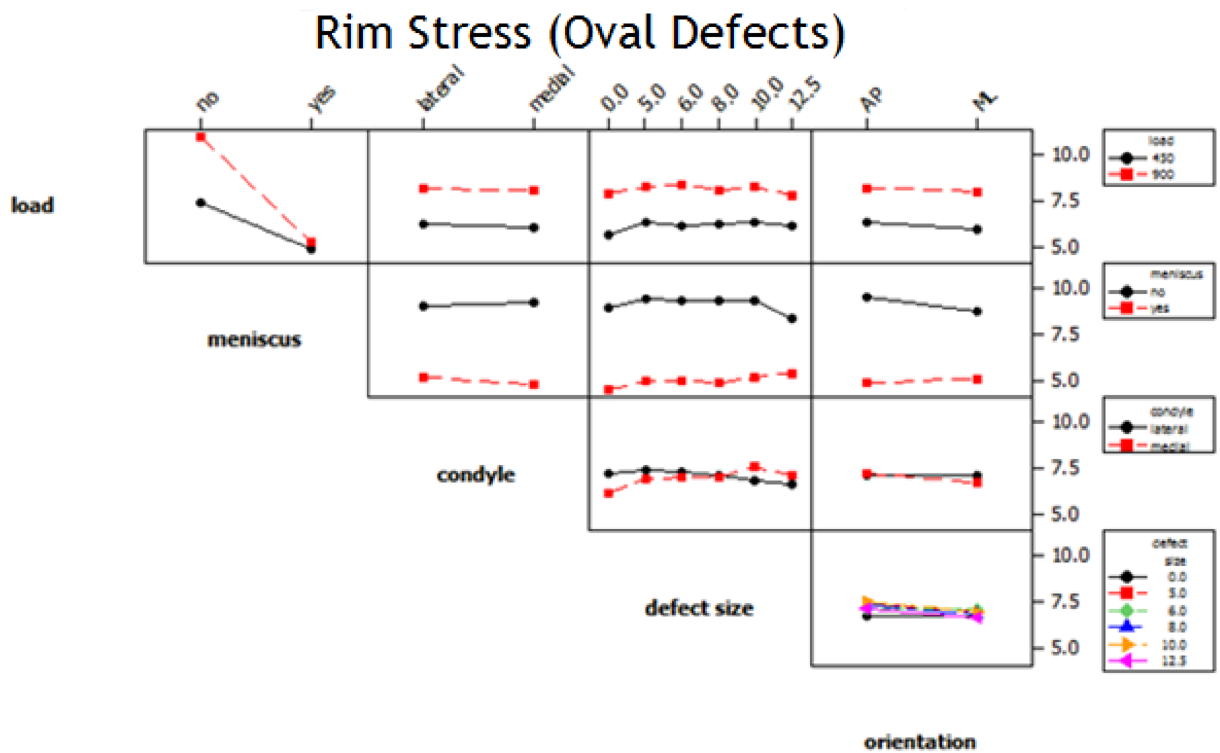

Figure 17: Factorial plots for the defect factor interactions affecting rim stress in oval defects

3.2.2 Subchondral Bone Contact in Oval Defects

Subchondral bone contact areas were generally greater in knees subjected to a higher load ($p = 0.008$), knees with no meniscus ($p < 0.001$), defects on the lateral condyle ($p = 0.001$), larger defect sizes ($p < 0.001$), and defects oriented in the medial-lateral direction ($p = 0.005$). Interactions between load size and defect orientation ($p < 0.001$), condyle and presence of a meniscus ($p = 0.001$), defect size and presence of a meniscus ($p < 0.001$), condyle and defect size ($p = 0.017$), and defect size and orientation ($p = 0.015$) significantly affected the development of subchondral bone contact in oval defects.

	Load	Meniscus	Condyle	Defect Size	Orientation
Load	**0.008**	X	X	X	X
Meniscus	0.133	**<0.001**	X	X	X
Condyle	0.143	**0.001**	**0.001**	X	X
Defect Size	0.063	**<0.001**	**0.017**	**<0.001**	X
Orientation	**<0.001**	0.100	0.363	**0.015**	**0.005**

Table 6: P-values to determine significance of the individual defect factors and their interactions on subchondral bone contact in oval defects. Bolded values indicate statistical significance (significant for $p < 0.05$).

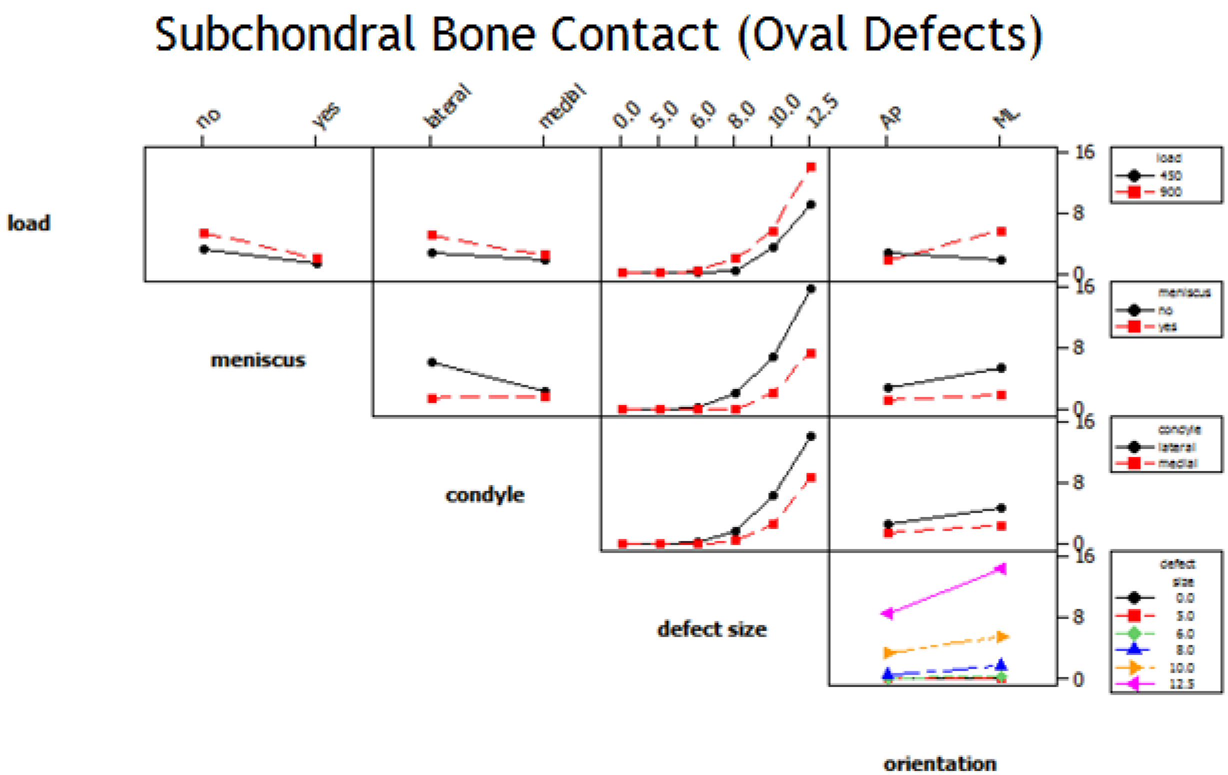

Figure 22: Factorial plots for the defect factor interactions affecting subchondral bone contact in oval defects

3.3 Circle and Oval Defect Combined Analyses

3.3.1 Effects on Peak Pressure

In the combined statistical analysis of circle and oval-shaped defects, peak pressures around the rim of a defect was found to be higher in knees subjected to higher loads ($p < 0.001$), knees with no mensici ($p < 0.001$), and defects with larger anterior-posterior dimension ($p = 0.039$). Interactions affecting rim stress were between magnitude of load and presence of a meniscus ($p < 0.001$), condyle and defect orientation ($p = 0.002$), and medial-lateral dimension and presence of a meniscus ($p < 0.001$).

	Load	Meniscus	Condyle	AP Dimension	ML Dimension
Load	**<0.001**	X	X	X	X
Meniscus	**<0.001**	**<0.001**	X	X	X
Condyle	0.882	0.057	0.820	X	X
AP Dimension	0.121	0.479	**0.002**	**0.039**	X
ML Dimension	0.268	**<0.001**	0.553	(0.256)	0.513

Table 7: P-values to determine significance of the individual defect factors and their interactions on rim stress in a combined dimensional analysis. Bolded values indicate statistical significance (significant for $p < 0.05$).

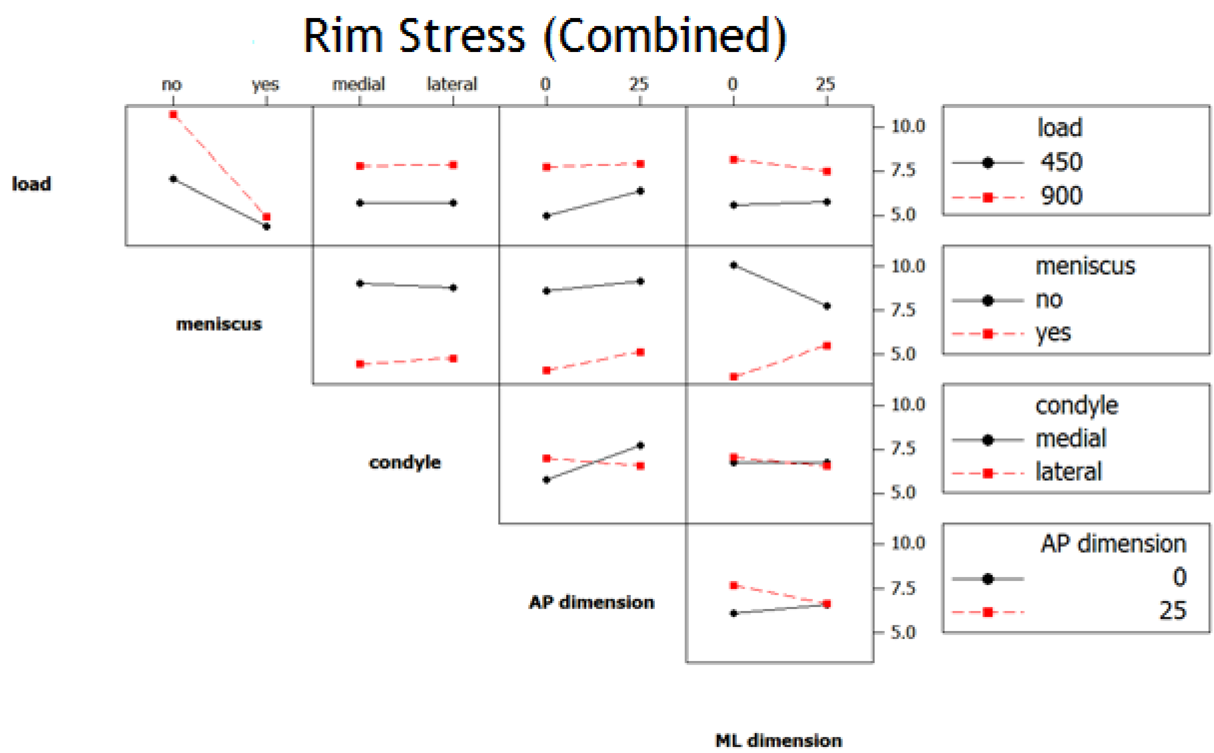

Figure 19: Factorial plots showing the effects of combined data factors on rim stress

3.3.2 Effects on Subchondral Bone Contact

Larger areas of subchondral bone contact were generally seen in knees at higher loads ($p < 0.001$), knees with no meniscus ($p < 0.001$), knees with defects on the lateral condyle ($p < 0.001$), defects with larger anterior-posterior dimensions ($p < 0.001$), and knees with larger medial-lateral dimensions ($p < 0.001$). All of the possible two-factor interactions were found to contribute to the development of subchondral bone contact area. This includes the interactions between load size and presence of meniscus ($p = 0.030$), load size and condyle ($p = 0.014$), load size and anterior-posterior dimension ($p = 0.038$), load size and medial-lateral dimension ($p < 0.001$), condyle and presence of a meniscus ($p < 0.001$), defect size and presence of a meniscus ($p = 0.002$), medial-lateral orientation and presence of a meniscus ($p < 0.001$), condyle and anterior-posterior dimension ($p = 0.013$), condyle and medial-lateral dimension ($p < 0.001$).

	Load	Meniscus	Condyle	AP Dimension	ML Dimension
Load	**<0.001**	X	X	X	X
Meniscus	**0.030**	**<0.001**	X	X	X
Condyle	**0.014**	**<0.001**	**<0.001**	X	X
AP Dimension	**0.038**	**0.002**	**0.013**	**<0.001**	X
ML Dimension	**<0.001**	**<0.001**	**<0.001**	**(<0.001)**	**<0.001**

Table 8: P-values to determine significance of the individual defect factors and their interactions on subchondral bone contact in a combined dimensional analysis. Bolded values indicate statistical significance (significant for $p < 0.05$).

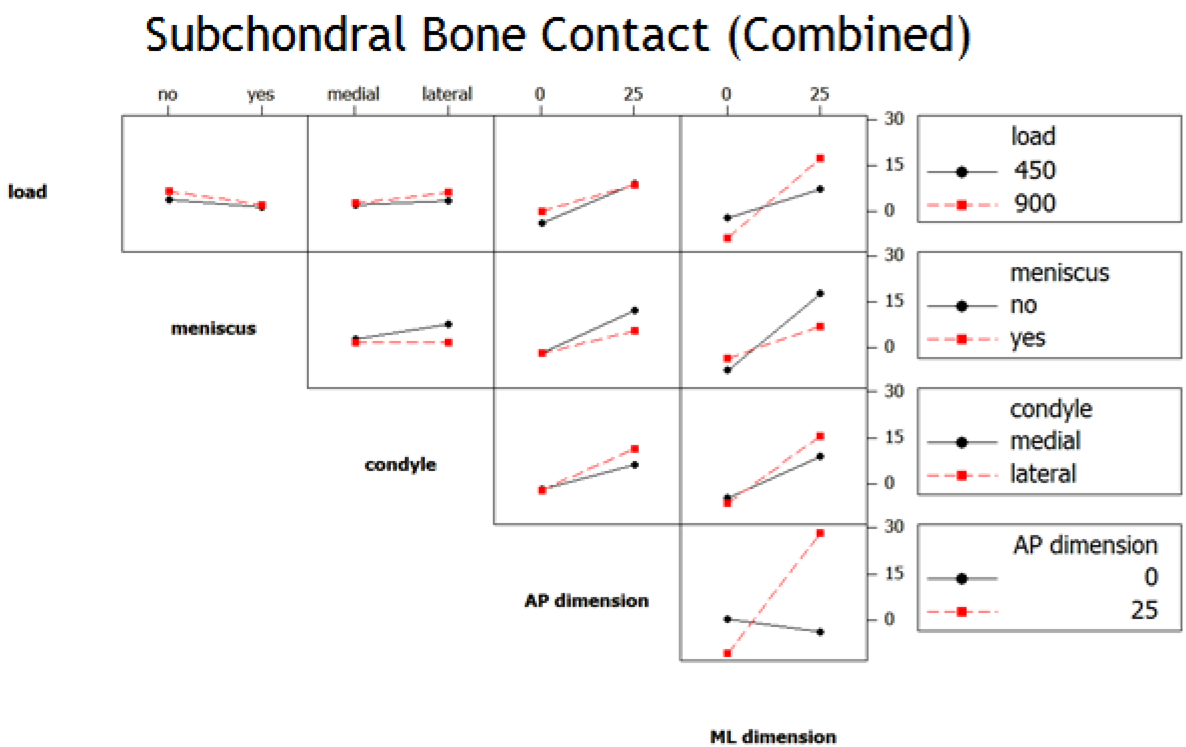

Figure 20: Factorial plots showing the effects of combined data factors on subchondral bone contact.

3.4.1 Summary of Results

	Rim Stress	Subchondral Bone Contact
Circle Defect Analysis	Load **Meniscus** **Condyle** Load*Meniscus	**Meniscus** **Condyle** Defect Size Meniscus*Condyle Meniscus*Defect Size Condyle*Defect Size
Oval Defect Analysis	**Load** **Meniscus** Load*Meniscus Meniscus*Orientation **Condyle*Defect Size**	**Load** **Meniscus** Condyle Defect Size Orientation Load*Orientation Meniscus*Condyle Meniscus*Defect Size **Condyle*Defect Size** Defect Size*Orientation
Combined Dimensional Analysis	**Load** **Meniscus** **AP Dimension** **Load*Meniscus** **Meniscus*ML Dimension** **Condyle*AP Dimension**	**Load** **Meniscus** Condyle **AP Dimension** ML Dimension **Load*Meniscus** Load*Condyle Load*AP Dimension Load*ML Dimension Meniscus*Condyle Meniscus*AP Dimension **Meniscus*ML Dimension** **Condyle*AP Dimension** Condyle*ML Dimension AP Dimension*ML Dimension

Figure 21: Summary of significant main and interaction effects of defect factors on rim stress and SBC for the circle defect, oval defect, and combined dimensional analyses. Bolded factors for each analysis indicate a significant impact on the development of both mechanisms of progression.

Chapter 4: Conclusion

4.1 Discussion of Circle Defect Results

Much of the previous work in this area has focused on determining the effects of circular defect factors on the development of rim stress. In this study, values of rim stress around circular defects were higher in knees subjected to higher loads, which is consistent with the results of previous studies [20, 22]. Also confirmed in previous studies, a lack of meniscus corresponded to higher peak pressures around the rim of the defect [15, 22]. The correlation between defects on the lateral condyle and higher rim stresses is consistent with previous findings [15]. Pressure distributions from this study indicated that contact stresses develop around the rim of the defect, however larger defect sizes were not linked to increasing peak pressure values; similar findings were reported in previous studies [12, 14, 16, 22]. Interaction effects between factors were not investigated in previous studies, however the data from this study showed evidence of a non-additive influence of load and meniscal factors on rim stress in circle defects.

The results of this study indicated that a lack of meniscus corresponded to larger areas of subchondral bone contact, which is consistent with previous findings [22]. Results from this study also confirmed previous findings that defects on the lateral condyle are linked to larger areas of SBC [19, 22]. Although defect size did not affect rim stress, the results of this study and past studies indicated that larger defect sizes are linked to the development of larger areas of SBC [19, 22]. The interaction analysis of this study showed that all possible two-way interactions between meniscus, condyle, and defect size were significant and contributed non-additive effects on the development of subchondral bone contact.

For circular defects, a lack of meniscus and a defect on the lateral condyle were the two primary individual factors that contributed to the development of both rim stress and subchondral bone contact. Though it is unclear which mechanism of progression dominates the growth of a cartilage defect, these findings indicate that the presence of either or both of these defect conditions in a specific patient is a definite risk factor for further defect growth. Large defect sizes and high loads each affected one of the two mechanisms of progression; these can be considered secondary risk factors. One limitation to the circle defect analysis is that these findings are specific to a circular defect geometry, and it is unlikely that a natural defect would be shaped as a perfect circle. It is important to compare these results to the effects of the non-circular defect factors in order to demonstrate the relevance of past findings to more realistic defect conditions.

4.2 Discussion of Oval Defect Results

To my knowledge, no previous studies have analyzed the effects of oval defect factors on the development of rim stress. The results of this study indicated that higher loads in knees with no meniscus contributed non-additive interaction effects on rim stress. A significant interaction existed between defect size and condyle where larger defects on the lateral condyle yielded higher values of rim stress; however, neither defect size nor condyle were significant single factors affecting rim stress around oval defects. The interaction between meniscus and orientation indicated that anterior-posterior oriented defects in knees with no meniscus experienced larger rim stresses, however orientation was not significant as a single factor.

The results of this study indicated that individual factors contributing to larger areas of subchondral bone contact in oval defects are higher loads, a lack of meniscus, defects on the lateral condyle, larger defect sizes, and medial-lateral oriented defects. These results are consistent with previous findings that have investigated condyle, defect size, and orientation, however no other known study has investigated load and meniscal effects of oval defects on SBC [21]. The results from this study also showed that interactions between larger defects on the lateral condyle and larger defects with a medial-lateral orientation contribute to larger areas of SBC, which is consistent with previous findings [21]. Results from this study also indicated that interactions of medial-lateral orientations at higher loads as well as defects on the lateral condyle with no meniscus yielded larger areas of SBC. Generally larger defect areas and no meniscus produced larger areas of SBC.

Higher loads and knees with no meniscus were single factors shown to yield higher values of both rim stress and subchondral bone contact in oval defects. This means that patients with knees subjected to high loads or patients with a history of meniscectomy are at high risk of contributing to the development of both mechanisms of defect progression. The interaction between defect size and condyle also affected both mechanisms of progression; however large defects on the medial condyle contributed to the progression of rim stress while large defects on the lateral condyle contributed to the progression of subchondral bone contact. All believed factors of progression contribute in some way (as a single factor or as part of an interaction effect) to both rim stress and subchondral bone contact.

4.3 Comparison of Circle and Oval Defect Analyses

In both the circle and oval defect analyses, high loads, knees with no meniscus, and the interaction between these factors contributed to higher values of rim stress. Both analyses also reported that defect size was not significant as a single factor in the progression of rim stress (defect size was only significant as an interaction with condyle for oval defects). Circle and oval defect analyses also determined significant effects of meniscus, condyle, defect size, and their associated interactions on the development of subchondral bone contact. However, load was found to be a significant single factor affecting SBC in oval defects, but not circle defects. This can be explained by the fact that fewer circle defects produced any subchondral bone contact, especially when a meniscus was present. Load may have become a significant factor had the contact surface geometry allowed subchondral bone contact at overall smaller defect areas. In addition, the oval defect analysis indicated that the additional factor, orientation, had a statistically significant impact on SBC area. From this comparison of results, we can determine that the results from circle and oval defect studies are generally consistent; however defect shape is a significant factor that in some way affects both rim stress and subchondral bone contact and should be accounted for.

4.4 Dimensional Analysis Discussion

One shortcoming in the circle and oval defect analyses is that data investigating the believed factors of defect progression were separated based on the shape of the defect. Including all data in a comprehensive statistical analysis provides better support for the conclusion of the effects of defect factors on the mechanisms of progression. Another motivation in combining the circle and oval defect data into a single analysis is that both orientation and defect size could be eliminated as factors and replaced by medial-lateral and anterior-posterior orientation dimensions. Since natural defects are not likely to be perfect circles or ovals in exact medial-lateral or anterior-posterior orientations, determining the effects separate defect dimensions can be useful in a clinical setting.

In the combined dimensional analysis, high loads, no meniscus, and large AP dimensions were single factors that led to higher rim stresses. Interactions between factors indicated that high loads and no meniscus yielded higher peak pressures around the rim. Smaller ML dimensions in knees with no meniscus also produced higher values of rim stress, but ML dimension was not significant as an individual factor. Non-additive effects were found to occur between condyle and AP dimension factors, but condyle was not a significant single factor.

For the combined dimensional analysis, all single factors were significant: higher loads, no meniscus, lateral condyle, larger AP dimensions, and larger ML dimensions individually yielded larger areas of subchondral bone contact. Additionally, all interactions between single factors contributed non-additive effects on the development of SBC. An interesting interaction occurred between the AP dimension and the ML dimension factors: in defects where both dimensions are generally small, the ML dimension is the factor that dominates the development of subchondral bone contact. However when both dimensions are generally larger, the AP dimension dominates the subchondral bone contact development.

4.5 Significance of Results

The results of the circle, oval, and dimensional analyses all indicated that high loads, no meniscus, and high loads on knees with no meniscus were factors contributing to high rim stresses around the area of the defect. In both analyses including orientation as a factor, large AP dimensions contributed to the development of rim stress as either or a single factor or part of an interaction. Although defect size was not a significant single factor for circular defects, the more realistic asymmetric defect analyses indicated that defect size or dimension would likely impact rim stress as a part of an interaction with another factor. All analyses indicated condyle as either a significant single factor or interaction, and the circle and oval defect analyses showed the lateral condyle as the factor contributing to higher rim stresses. From the comparison of these three analyses, we can determine that patients with knees exposed to high loads and a history of meniscectomy are at high risk for defect growth through the mechanism of rim stress development. Despite slight inconsistencies between analyses, there is evidence that suggest that large defect sizes, defects with an anterior-posterior orientation, and defects on the lateral condyle are additional factors that contribute to the development of rim stress.

The results of the circle, oval, and dimensional analyses indicated that a lack of meniscus, defects of the lateral condyle, and larger defect sizes (overall size and each dimension) contributed to the development of subchondral bone contact as single factors. These factors were also significant throughout the analyses as interactions with other factors. Orientation was seen as a significant single factor and interaction factor in the oval defect analysis and the dimensional analysis. Large loads were also determined to contribute to subchondral bone contact development in the oval defect and dimensional analyses. The comparison of these results indicate that patients with large defect sizes in both the AP and ML dimension, defects of the lateral condyle, and a history of meniscectomy are at a definite risk for furthering defect progression through subchondral bone contact development. Despite inconsistencies between analyses, there is also reason to believe that knees subjected to higher loads are also at risk for defect progression through subchondral bone contact.

The comparison of circle and oval shaped defects in a single study was important to compare the results of studies using different defect shapes. Similar results were obtained between the two data sets, however it was determined that defect orientation is a significant factor affecting both mechanism of progression and should be accounted for in future studies.

The dimensional analysis provided more detail about the effects of medial-lateral and anterior-posterior defect dimensions on rim stress and subchondral bone contact. This analysis can provide information useful in a clinical setting where individual defects may grow directionally. From the comparison of these analyses, we can find information useful in determining the factors likely contributing to each mechanism of defect progression. Although it is not clear which factor dominates defect progression, we can conclude that patients with a history of meniscectomy are at a definite risk for defect progression through either rim stress or SBC development. High loads, defects of the lateral condyle, and defect orientation are additional factors that likely contribute to the progression of both mechanisms. Large defect size is seemingly more significant for the development of subchondral bone contact than rim stress.

The instances of interaction effects between one or more factors that did not contribute a significant single factor effect indicate the necessity of future studies to include interaction analyses. The impact of these factors on the development of progression mechanisms would be neglected in an analysis which only determined the main effects of the defect factors. It is important to investigate all contributions to rim stress and SBC to obtain a comprehensive understanding of the knee and defect conditions that contribute to defect progression. The interaction analyses may provide more detailed information about the specific conditions of factors that contribute to defect progression.

4.6 Shortcomings and Future Work

This study was not without shortcomings. One possible source of error was that very few instances of subchondral bone contact occurred in circular defects subjected to low loads with intact menisci. Load was found to be a significant factor affecting subchondral bone contact development in all categories except in circular defects. The lack of data points in this category may have affected the statistical analysis, causing load to be seen as insignificant under these conditions. This phenomenon could be further investigated by exploring higher loading conditions to determine the role of load size on subchondral bone contact development.

For large oval defects, the ML dimension sometimes exceeded the width of the articular surface in knees with smaller bone geometry. This can explain why in the dimensional analysis, SBC development was dominated by the AP dimension in generally larger defects, but by the ML dimension in generally smaller defects. At that point the medial-lateral dimension could not change, but the anterior-posterior dimension was still increasing as the size of the coring punches increased. Since the AP direction was the only dimension that grew at larger defect sizes, this was the dimension that controlled the overall increase in defect size and could contribute to the development of SBC. However for defects that still fit on the area of the articular surface, the ML dimension dominated subchondral bone contact development. This is consistent with the previous study that analyzed the effects of orientation on SBC for bovine knees [21]. The effect of bone geometry could be further explored in a dimensional analysis similar to that of this study, but with bovine knee subjects. For larger knee geometries, the defect sizes of interest would not be limited by the area of the articular surface. This topic could also be further investigated by analyzing three-dimensional bone scans of each porcine knee from this study. With this information, it can be determined if the size of the original articular surface is an additional interaction factor affecting the development of rim stress and subchondral bone contact.

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Appendix A: Raw Data for Circle and Oval Shaped Defects

Knee	Shape	Load	Meniscus	Condyle	Defect Size	Orientation	Peak Pressure	SBC
1	oval	900	yes	medial	0	ML	5.98	0
1	oval	900	yes	medial	5	ML	7.93	0
1	oval	900	yes	medial	6	ML	9.96	0
1	oval	900	yes	medial	8	ML	9.18	0
1	oval	900	yes	medial	10	ML	11.97	9.69
1	oval	900	yes	medial	12.5	ML	10.89	95.31
1	oval	900	yes	lateral	0	ML	10.79	0
1	oval	900	yes	lateral	5	ML	13.04	0
1	oval	900	yes	lateral	6	ML	11.78	0
1	oval	900	yes	lateral	8	ML	10.6	0
1	oval	900	yes	lateral	10	ML	5.16	50.08
1	oval	900	yes	lateral	12.5	ML	7.52	90.46
2	oval	900	yes	medial	0	ML	2.24	0
2	oval	900	yes	medial	5	ML	2.41	0
2	oval	900	yes	medial	6	ML	2.47	0
2	oval	900	yes	medial	8	ML	2.5	0
2	oval	900	yes	medial	10	ML	2.68	0
2	oval	900	yes	medial	12.5	ML	2.81	0
2	oval	900	yes	lateral	0	AP	2.58	0
2	oval	900	yes	lateral	5	AP	2.7	0
2	oval	900	yes	lateral	6	AP	2.46	0
2	oval	900	yes	lateral	8	AP	2.31	0
2	oval	900	yes	lateral	10	AP	2.5	0
2	oval	900	yes	lateral	12.5	AP	2.29	0
3	oval	900	yes	medial	0	AP	2.63	0
3	oval	900	yes	medial	5	AP	2.68	0
3	oval	900	yes	medial	6	AP	2.69	0
3	oval	900	yes	medial	8	AP	2.66	0
3	oval	900	yes	medial	10	AP	2.66	0
3	oval	900	yes	medial	12.5	AP	2.73	0
3	oval	900	yes	lateral	0	ML	2.6	0
3	oval	900	yes	lateral	5	ML	2.66	0
3	oval	900	yes	lateral	6	ML	2.64	0
3	oval	900	yes	lateral	8	ML	2.68	0
3	oval	900	yes	lateral	10	ML	2.73	0
3	oval	900	yes	lateral	12.5	ML	2.85	0
4	oval	900	yes	medial	0	ML	2.13	0
4	oval	900	yes	medial	5	ML	3.24	0

4	oval	900	yes	medial	6	ML	3.39	0
4	oval	900	yes	medial	8	ML	3.19	0
4	oval	900	yes	medial	10	ML	3.65	0
4	oval	900	yes	medial	12.5	ML	4.3	4.85
4	oval	900	yes	lateral	0	AP	6.38	0
4	oval	900	yes	lateral	5	AP	6.58	0
4	oval	900	yes	lateral	6	AP	6.53	0
4	oval	900	yes	lateral	8	AP	7.29	0
4	oval	900	yes	lateral	10	AP	6.63	0
4	oval	900	yes	lateral	12.5	AP	5.77	0
5	oval	900	yes	medial	0	AP	7.05	0
5	oval	900	yes	medial	5	AP	7.11	0
5	oval	900	yes	medial	6	AP	7.37	0
5	oval	900	yes	medial	8	AP	7.44	0
5	oval	900	yes	medial	10	AP	6.73	0
5	oval	900	yes	medial	12.5	AP	6.53	0
5	oval	900	yes	lateral	0	ML	3.95	0
5	oval	900	yes	lateral	5	ML	5.04	0
5	oval	900	yes	lateral	6	ML	4.27	0
5	oval	900	yes	lateral	8	ML	4.92	0
5	oval	900	yes	lateral	10	ML	5.04	0
5	oval	900	yes	lateral	12.5	ML	4.27	0
6	oval	900	yes	medial	0	ML	3.72	0
6	oval	900	yes	medial	5	ML	4.19	0
6	oval	900	yes	medial	6	ML	4.55	0
6	oval	900	yes	medial	8	ML	4.08	0
6	oval	900	yes	medial	10	ML	4.96	0
6	oval	900	yes	medial	12.5	ML	6.51	0
6	oval	900	yes	lateral	0	ML	4.6	0
6	oval	900	yes	lateral	5	ML	4.75	0
6	oval	900	yes	lateral	6	ML	6.05	0
6	oval	900	yes	lateral	8	ML	5.32	0
6	oval	900	yes	lateral	10	ML	4.96	0
6	oval	900	yes	lateral	12.5	ML	7.03	0
7	oval	900	yes	medial	0	AP	5.89	0
7	oval	900	yes	medial	5	AP	6.54	0
7	oval	900	yes	medial	6	AP	6.49	0
7	oval	900	yes	medial	8	AP	6.22	0
7	oval	900	yes	medial	10	AP	5.46	0
7	oval	900	yes	medial	12.5	AP	5.52	0
7	oval	900	yes	lateral	0	AP	3.51	0

7	oval	900	yes	lateral	5	AP	4.92	0
7	oval	900	yes	lateral	6	AP	4.43	0
7	oval	900	yes	lateral	8	AP	4.65	0
7	oval	900	yes	lateral	10	AP	4.54	0
7	oval	900	yes	lateral	12.5	AP	4.6	19.38
8	oval	900	yes	medial	0	ML	2.87	0
8	oval	900	yes	medial	5	ML	2.71	0
8	oval	900	yes	medial	6	ML	3.03	0
8	oval	900	yes	medial	8	ML	3.28	0
8	oval	900	yes	medial	10	ML	3.35	0
8	oval	900	yes	medial	12.5	ML	3.99	8.08
8	oval	900	yes	lateral	0	ML	3.91	0
8	oval	900	yes	lateral	5	ML	4.66	0
8	oval	900	yes	lateral	6	ML	5.04	0
8	oval	900	yes	lateral	8	ML	4.9	0
8	oval	900	yes	lateral	10	ML	5.01	3.23
8	oval	900	yes	lateral	12.5	ML	4.61	16.15
9	oval	900	yes	medial	0	ML	7.95	0
9	oval	900	yes	medial	5	ML	9.38	0
9	oval	900	yes	medial	6	ML	10.37	0
9	oval	900	yes	medial	8	ML	11.45	0
9	oval	900	yes	medial	10	ML	11.82	16.15
9	oval	900	yes	medial	12.5	ML	7.78	56.54
9	oval	900	yes	lateral	0	ML	7.65	0
9	oval	900	yes	lateral	5	ML	10.44	0
9	oval	900	yes	lateral	6	ML	11.65	0
9	oval	900	yes	lateral	8	ML	12.22	0
9	oval	900	yes	lateral	10	ML	12.46	0
9	oval	900	yes	lateral	12.5	ML	10.09	0
10	oval	900	yes	medial	0	AP	7.93	0
10	oval	900	yes	medial	5	AP	8.37	0
10	oval	900	yes	medial	6	AP	7.62	0
10	oval	900	yes	medial	8	AP	6.15	0
10	oval	900	yes	medial	10	AP	6.79	0
10	oval	900	yes	medial	12.5	AP	7.85	0
10	oval	900	yes	lateral	0	AP	7.68	0
10	oval	900	yes	lateral	5	AP	8.02	0
10	oval	900	yes	lateral	6	AP	9.03	0
10	oval	900	yes	lateral	8	AP	5.16	0
10	oval	900	yes	lateral	10	AP	7.05	0
10	oval	900	yes	lateral	12.5	AP	2.58	0

11	oval	900	yes	medial	0	AP	5.3	0
11	oval	900	yes	medial	5	AP	5.13	0
11	oval	900	yes	medial	6	AP	4.65	0
11	oval	900	yes	medial	8	AP	5.54	0
11	oval	900	yes	medial	10	AP	5.95	0
11	oval	900	yes	medial	12.5	AP	5.77	0
11	oval	900	yes	lateral	0	ML	6.3	0
11	oval	900	yes	lateral	5	ML	4.48	0
11	oval	900	yes	lateral	6	ML	6.36	0
11	oval	900	yes	lateral	8	ML	6.6	0
11	oval	900	yes	lateral	10	ML	5.89	0
11	oval	900	yes	lateral	12.5	ML	6.24	0
12	oval	900	yes	medial	0	AP	8.07	0
12	oval	900	yes	medial	5	AP	8.25	0
12	oval	900	yes	medial	6	AP	8.49	0
12	oval	900	yes	medial	8	AP	7.64	0
12	oval	900	yes	medial	10	AP	8	0
12	oval	900	yes	medial	12.5	AP	6.72	0
12	oval	900	yes	lateral	0	ML	7.15	0
12	oval	900	yes	lateral	5	ML	5.38	0
12	oval	900	yes	lateral	6	ML	7.15	0
12	oval	900	yes	lateral	8	ML	7.7	0
12	oval	900	yes	lateral	10	ML	7.45	0
12	oval	900	yes	lateral	12.5	ML	8.31	8.08
13	oval	900	yes	medial	0	ML	7.23	0
13	oval	900	yes	medial	5	ML	5.71	0
13	oval	900	yes	medial	6	ML	6.47	0
13	oval	900	yes	medial	8	ML	5.56	0
13	oval	900	yes	medial	10	ML	6.55	0
13	oval	900	yes	medial	12.5	ML	6.85	0
13	oval	900	yes	lateral	0	ML	2.89	0
13	oval	900	yes	lateral	5	ML	3.12	0
13	oval	900	yes	lateral	6	ML	3.42	0
13	oval	900	yes	lateral	8	ML	3.58	0
13	oval	900	yes	lateral	10	ML	3.73	0
13	oval	900	yes	lateral	12.5	ML	3.88	0
14	oval	900	yes	medial	0	AP	2.65	0
14	oval	900	yes	medial	5	AP	2.46	0
14	oval	900	yes	medial	6	AP	2.44	0
14	oval	900	yes	medial	8	AP	2.78	0
14	oval	900	yes	medial	10	AP	2.53	0

14	oval	900	yes	medial	12.5	AP	2.78	0
14	oval	900	yes	lateral	0	AP	2.71	0
14	oval	900	yes	lateral	5	AP	2.69	0
14	oval	900	yes	lateral	6	AP	2.72	0
14	oval	900	yes	lateral	8	AP	2.98	0
14	oval	900	yes	lateral	10	AP	2.36	0
14	oval	900	yes	lateral	12.5	AP	2.41	22.62
15	oval	900	yes	medial	0	ML	2.3	0
15	oval	900	yes	medial	5	ML	2.41	0
15	oval	900	yes	medial	6	ML	2.31	0
15	oval	900	yes	medial	8	ML	2.47	0
15	oval	900	yes	medial	10	ML	2.55	0
15	oval	900	yes	medial	12.5	ML	2.62	0
15	oval	900	yes	lateral	0	AP	2.5	0
15	oval	900	yes	lateral	5	AP	2.23	0
15	oval	900	yes	lateral	6	AP	2.26	0
15	oval	900	yes	lateral	8	AP	2.37	0
15	oval	900	yes	lateral	10	AP	2.34	0
15	oval	900	yes	lateral	12.5	AP	2.61	0
16	oval	900	yes	medial	0	ML	2.41	0
16	oval	900	yes	medial	5	ML	2.45	0
16	oval	900	yes	medial	6	ML	2.48	0
16	oval	900	yes	medial	8	ML	2.48	0
16	oval	900	yes	medial	10	ML	2.53	0
16	oval	900	yes	medial	12.5	ML	2.42	0
16	oval	900	yes	lateral	0	AP	2.65	0
16	oval	900	yes	lateral	5	AP	2.29	0
16	oval	900	yes	lateral	6	AP	2.4	0
16	oval	900	yes	lateral	8	AP	2.43	0
16	oval	900	yes	lateral	10	AP	2.71	0
16	oval	900	yes	lateral	12.5	AP	2.21	0
17	oval	900	yes	medial	0	AP	4.05	0
17	oval	900	yes	medial	5	AP	2.74	0
17	oval	900	yes	medial	6	AP	2.68	0
17	oval	900	yes	medial	8	AP	3.07	0
17	oval	900	yes	medial	10	AP	3.46	0
17	oval	900	yes	medial	12.5	AP	3.59	0
17	oval	900	yes	lateral	0	AP	6.4	0
17	oval	900	yes	lateral	5	AP	7.84	0
17	oval	900	yes	lateral	6	AP	4.64	0
17	oval	900	yes	lateral	8	AP	4.83	0

17	oval	900	yes	lateral	10	AP	4.25	3.23
17	oval	900	yes	lateral	12.5	AP	4.64	24.23
18	oval	900	yes	medial	0	AP	4.77	0
18	oval	900	yes	medial	5	AP	5.94	0
18	oval	900	yes	medial	6	AP	5.88	0
18	oval	900	yes	medial	8	AP	4.93	0
18	oval	900	yes	medial	10	AP	5.22	0
18	oval	900	yes	medial	12.5	AP	5.29	8.08
18	oval	900	yes	lateral	0	ML	3.79	0
18	oval	900	yes	lateral	5	ML	5.36	0
18	oval	900	yes	lateral	6	ML	4.96	0
18	oval	900	yes	lateral	8	ML	4.9	0
18	oval	900	yes	lateral	10	ML	4.18	0
18	oval	900	yes	lateral	12.5	ML	3.59	0
19	oval	900	yes	medial	0	ML	3.13	0
19	oval	900	yes	medial	5	ML	3.98	0
19	oval	900	yes	medial	6	ML	3.79	0
19	oval	900	yes	medial	8	ML	4.38	0
19	oval	900	yes	medial	10	ML	4.18	0
19	oval	900	yes	medial	12.5	ML	4.9	14.54
19	oval	900	yes	lateral	0	AP	5.88	0
19	oval	900	yes	lateral	5	AP	6.2	0
19	oval	900	yes	lateral	6	AP	6.01	0
19	oval	900	yes	lateral	8	AP	6.53	0
19	oval	900	yes	lateral	10	AP	5.49	0
19	oval	900	yes	lateral	12.5	AP	4.9	0
83	oval	900	yes	medial	0	AP	3.49	0
83	oval	900	yes	medial	5	AP	5.01	0
83	oval	900	yes	medial	6	AP	4.92	0
83	oval	900	yes	medial	8	AP	5.01	0
83	oval	900	yes	medial	10	AP	10.02	0
83	oval	900	yes	medial	12.5	AP	12.89	0
83	oval	900	yes	lateral	0	AP	4.03	0
83	oval	900	yes	lateral	5	AP	4.39	0
83	oval	900	yes	lateral	6	AP	4.83	0
83	oval	900	yes	lateral	8	AP	5.37	0
83	oval	900	yes	lateral	10	AP	6.98	0
83	oval	900	yes	lateral	12.5	AP	6.44	0
21	oval	900	no	medial	0	AP	5.76	0
21	oval	900	no	medial	5	AP	9.89	0
21	oval	900	no	medial	6	AP	8.36	0

21	oval	900	no	medial	8	AP	11.33	0
21	oval	900	no	medial	10	AP	9.53	0
21	oval	900	no	medial	12.5	AP	9.71	0
21	oval	900	no	lateral	0	ML	2.25	0
21	oval	900	no	lateral	5	ML	10.61	0
21	oval	900	no	lateral	6	ML	10.43	0
21	oval	900	no	lateral	8	ML	7.2	0
21	oval	900	no	lateral	10	ML	6.93	0
21	oval	900	no	lateral	12.5	ML	5.31	0
22	oval	900	no	medial	0	AP	8.75	0
22	oval	900	no	medial	5	AP	8.27	0
22	oval	900	no	medial	6	AP	9.32	0
22	oval	900	no	medial	8	AP	9.41	0
22	oval	900	no	medial	10	AP	10.65	0
22	oval	900	no	medial	12.5	AP	10.94	0
22	oval	900	no	lateral	0	AP	9.03	0
22	oval	900	no	lateral	5	AP	11.22	0
22	oval	900	no	lateral	6	AP	9.22	0
22	oval	900	no	lateral	8	AP	11.03	0
22	oval	900	no	lateral	10	AP	10.46	0
22	oval	900	no	lateral	12.5	AP	10.75	6.46
23	oval	900	no	medial	0	AP	12.17	0
23	oval	900	no	medial	5	AP	11.79	0
23	oval	900	no	medial	6	AP	11.7	0
23	oval	900	no	medial	8	AP	12.27	0
23	oval	900	no	medial	10	AP	11.22	0
23	oval	900	no	medial	12.5	AP	7.13	0
23	oval	900	no	lateral	0	AP	9.79	0
23	oval	900	no	lateral	5	AP	11.6	0
23	oval	900	no	lateral	6	AP	11.03	0
23	oval	900	no	lateral	8	AP	13.22	0
23	oval	900	no	lateral	10	AP	17.4	0
23	oval	900	no	lateral	12.5	AP	10.08	0
24	oval	900	no	medial	0	AP	8.84	0
24	oval	900	no	medial	5	AP	8.56	0
24	oval	900	no	medial	6	AP	8.46	0
24	oval	900	no	medial	8	AP	11.32	0
24	oval	900	no	medial	10	AP	10.65	0
24	oval	900	no	medial	12.5	AP	10.94	0
24	oval	900	no	lateral	0	ML	12.84	0
24	oval	900	no	lateral	5	ML	13.12	0

24	oval	900	no	lateral	6	ML	11.6	0
24	oval	900	no	lateral	8	ML	12.17	0
24	oval	900	no	lateral	10	ML	11.98	6.46
24	oval	900	no	lateral	12.5	ML	7.7	29.08
25	oval	900	no	medial	0	AP	9.41	0
25	oval	900	no	medial	5	AP	8.65	0
25	oval	900	no	medial	6	AP	9.32	0
25	oval	900	no	medial	8	AP	12.74	0
25	oval	900	no	medial	10	AP	14.36	0
25	oval	900	no	medial	12.5	AP	10.46	0
25	oval	900	no	lateral	0	ML	9.79	0
25	oval	900	no	lateral	5	ML	12.08	0
25	oval	900	no	lateral	6	ML	12.17	0
25	oval	900	no	lateral	8	ML	13.22	3.23
25	oval	900	no	lateral	10	ML	9.79	35.54
25	oval	900	no	lateral	12.5	ML	10.84	58.15
26	oval	900	no	medial	0	ML	10.16	0
26	oval	900	no	medial	5	ML	11.86	0
26	oval	900	no	medial	6	ML	13.17	0
26	oval	900	no	medial	8	ML	12.83	0
26	oval	900	no	medial	10	ML	14.06	3.23
26	oval	900	no	medial	12.5	ML	13.64	19.38
26	oval	900	no	lateral	0	AP	11.32	0
26	oval	900	no	lateral	5	AP	17.27	0
26	oval	900	no	lateral	6	AP	21.14	0
26	oval	900	no	lateral	8	AP	15.5	0
26	oval	900	no	lateral	10	AP	10.58	19.38
26	oval	900	no	lateral	12.5	AP	7.38	30.69
27	oval	900	no	medial	0	ML	13.76	0
27	oval	900	no	medial	5	ML	11.43	0
27	oval	900	no	medial	6	ML	13.48	0
27	oval	900	no	medial	8	ML	10.17	0
27	oval	900	no	medial	10	ML	15.93	0
27	oval	900	no	medial	12.5	ML	8.26	42
27	oval	900	no	lateral	0	ML	15.88	0
27	oval	900	no	lateral	5	ML	10.19	0
27	oval	900	no	lateral	6	ML	10.87	0
27	oval	900	no	lateral	8	ML	12.3	0
27	oval	900	no	lateral	10	ML	7.7	0
27	oval	900	no	lateral	12.5	ML	11.11	6.46
28	oval	900	no	medial	0	AP	12.45	0

28	oval	900	no	medial	5	AP	15.06	0
28	oval	900	no	medial	6	AP	14.38	0
28	oval	900	no	medial	8	AP	9.5	0
28	oval	900	no	medial	10	AP	19.4	0
28	oval	900	no	medial	12.5	AP	19.74	0
28	oval	900	no	lateral	0	AP	9.69	0
28	oval	900	no	lateral	5	AP	13.18	0
28	oval	900	no	lateral	6	AP	14.07	0
28	oval	900	no	lateral	8	AP	9.79	0
28	oval	900	no	lateral	10	AP	10.29	21
28	oval	900	no	lateral	12.5	AP	9.11	35.54
29	oval	900	no	medial	0	ML	10.62	0
29	oval	900	no	medial	5	ML	12.31	0
29	oval	900	no	medial	6	ML	13.64	0
29	oval	900	no	medial	8	ML	8.21	0
29	oval	900	no	medial	10	ML	12.79	0
29	oval	900	no	medial	12.5	ML	10.98	0
29	oval	900	no	lateral	0	AP	12.19	0
29	oval	900	no	lateral	5	AP	12.43	0
29	oval	900	no	lateral	6	AP	11.83	0
29	oval	900	no	lateral	8	AP	8.45	0
29	oval	900	no	lateral	10	AP	8.33	0
29	oval	900	no	lateral	12.5	AP	10.74	0
30	oval	900	no	medial	0	AP	13.17	0
30	oval	900	no	medial	5	AP	12.83	0
30	oval	900	no	medial	6	AP	16.65	0
30	oval	900	no	medial	8	AP	18.73	0
30	oval	900	no	medial	10	AP	17.83	0
30	oval	900	no	medial	12.5	AP	19.85	0
30	oval	900	no	lateral	0	AP	17.68	0
30	oval	900	no	lateral	5	AP	11.19	0
30	oval	900	no	lateral	6	AP	10.3	0
30	oval	900	no	lateral	8	AP	8.35	0
30	oval	900	no	lateral	10	AP	7.38	0
30	oval	900	no	lateral	12.5	AP	7.05	12.92
31	oval	900	no	medial	0	ML	6.46	0
31	oval	900	no	medial	5	ML	10.58	0
31	oval	900	no	medial	6	ML	10.42	0
31	oval	900	no	medial	8	ML	3.57	0
31	oval	900	no	medial	10	ML	8.13	0
31	oval	900	no	medial	12.5	ML	12.8	0

31	oval	900	no	lateral	0	AP	21.49	0
31	oval	900	no	lateral	5	AP	16.14	0
31	oval	900	no	lateral	6	AP	11.04	0
31	oval	900	no	lateral	8	AP	9.96	0
31	oval	900	no	lateral	10	AP	7.26	0
31	oval	900	no	lateral	12.5	AP	6.02	0
32	oval	900	no	medial	0	ML	6.28	0
32	oval	900	no	medial	5	ML	8.45	0
32	oval	900	no	medial	6	ML	8.54	0
32	oval	900	no	medial	8	ML	9.18	0
32	oval	900	no	medial	10	ML	8.54	0
32	oval	900	no	medial	12.5	ML	8.22	0
32	oval	900	no	lateral	0	AP	10.87	0
32	oval	900	no	lateral	5	AP	10.2	0
32	oval	900	no	lateral	6	AP	10.21	0
32	oval	900	no	lateral	8	AP	12.04	0
32	oval	900	no	lateral	10	AP	12.54	0
32	oval	900	no	lateral	12.5	AP	11.44	0
33	oval	900	no	medial	0	ML	10.08	0
33	oval	900	no	medial	5	ML	11.34	0
33	oval	900	no	medial	6	ML	11.15	0
33	oval	900	no	medial	8	ML	10.7	0
33	oval	900	no	medial	10	ML	12.92	0
33	oval	900	no	medial	12.5	ML	9.61	0
33	oval	900	no	lateral	0	ML	16.11	0
33	oval	900	no	lateral	5	ML	10.76	0
33	oval	900	no	lateral	6	ML	11.03	0
33	oval	900	no	lateral	8	ML	9.59	12.92
33	oval	900	no	lateral	10	ML	8.12	42
33	oval	900	no	lateral	12.5	ML	8.12	58.15
34	oval	900	no	medial	0	AP	8.27	0
34	oval	900	no	medial	5	AP	8.04	0
34	oval	900	no	medial	6	AP	7.82	0
34	oval	900	no	medial	8	AP	8.53	0
34	oval	900	no	medial	10	AP	12.22	0
34	oval	900	no	medial	12.5	AP	13.14	0
34	oval	900	no	lateral	0	AP	13.41	0
34	oval	900	no	lateral	5	AP	9.51	0
34	oval	900	no	lateral	6	AP	9.97	0
34	oval	900	no	lateral	8	AP	11.65	0
34	oval	900	no	lateral	10	AP	14.08	0

34	oval	900	no	lateral	12.5	AP	11.4	27.46
35	oval	900	no	medial	0	ML	11.74	0
35	oval	900	no	medial	5	ML	13.51	0
35	oval	900	no	medial	6	ML	14.82	0
35	oval	900	no	medial	8	ML	11.25	0
35	oval	900	no	medial	10	ML	8.98	17.77
35	oval	900	no	medial	12.5	ML	7.92	43.62
35	oval	900	no	lateral	0	AP	9.48	0
35	oval	900	no	lateral	5	AP	12.95	0
35	oval	900	no	lateral	6	AP	14.1	0
35	oval	900	no	lateral	8	AP	17.02	0
35	oval	900	no	lateral	10	AP	15.22	22.62
35	oval	900	no	lateral	12.5	AP	13.6	30.69
36	oval	900	no	medial	0	AP	10.65	0
36	oval	900	no	medial	5	AP	9.73	0
36	oval	900	no	medial	6	AP	12.38	0
36	oval	900	no	medial	8	AP	13.79	21
36	oval	900	no	medial	10	AP	7.15	32.31
36	oval	900	no	medial	12.5	AP	9.96	48.46
36	oval	900	no	lateral	0	ML	13.78	0
36	oval	900	no	lateral	5	ML	18.97	0
36	oval	900	no	lateral	6	ML	17.38	19.38
36	oval	900	no	lateral	8	ML	11.58	40.38
36	oval	900	no	lateral	10	ML	13.71	50.08
36	oval	900	no	lateral	12.5	ML	14.96	66.23
37	oval	900	no	medial	0	AP	5.69	0
37	oval	900	no	medial	5	AP	8.14	0
37	oval	900	no	medial	6	AP	5.62	0
37	oval	900	no	medial	8	AP	8.5	0
37	oval	900	no	medial	10	AP	10.75	0
37	oval	900	no	medial	12.5	AP	10.43	0
37	oval	900	no	lateral	0	ML	9.47	0
37	oval	900	no	lateral	5	ML	10.47	0
37	oval	900	no	lateral	6	ML	9.14	0
37	oval	900	no	lateral	8	ML	7.57	21
37	oval	900	no	lateral	10	ML	8	37.15
37	oval	900	no	lateral	12.5	ML	8.96	69.46
38	oval	900	no	medial	0	ML	8.85	0
38	oval	900	no	medial	5	ML	9.47	0
38	oval	900	no	medial	6	ML	10.1	0
38	oval	900	no	medial	8	ML	12.16	0

38	oval	900	no	medial	10	ML	10.56	0
38	oval	900	no	medial	12.5	ML	7.53	0
38	oval	900	no	lateral	0	ML	9.75	0
38	oval	900	no	lateral	5	ML	10.67	0
38	oval	900	no	lateral	6	ML	10.13	0
38	oval	900	no	lateral	8	ML	11.03	12.92
38	oval	900	no	lateral	10	ML	8.28	24.23
38	oval	900	no	lateral	12.5	ML	7.86	38.77
39	oval	900	no	medial	0	ML	9.38	0
39	oval	900	no	medial	5	ML	9.29	0
39	oval	900	no	medial	6	ML	8.31	0
39	oval	900	no	medial	8	ML	7.72	12.92
39	oval	900	no	medial	10	ML	8.33	24.23
39	oval	900	no	medial	12.5	ML	4.6	38.77
39	oval	900	no	lateral	0	ML	9.38	0
39	oval	900	no	lateral	5	ML	7.1	0
39	oval	900	no	lateral	6	ML	7.89	0
39	oval	900	no	lateral	8	ML	8.35	0
39	oval	900	no	lateral	10	ML	7.65	0
39	oval	900	no	lateral	12.5	ML	6.7	0
40	oval	900	no	medial	0	ML	13.79	0
40	oval	900	no	medial	5	ML	13.13	0
40	oval	900	no	medial	6	ML	12.04	0
40	oval	900	no	medial	8	ML	11.62	0
40	oval	900	no	medial	10	ML	13.91	0
40	oval	900	no	medial	12.5	ML	10.53	32.31
40	oval	900	no	lateral	0	ML	17.12	0
40	oval	900	no	lateral	5	ML	7.21	0
40	oval	900	no	lateral	6	ML	12.74	0
40	oval	900	no	lateral	8	ML	9.67	19.38
40	oval	900	no	lateral	10	ML	7.46	21
40	oval	900	no	lateral	12.5	ML	10.97	61.38
85	oval	450	no	medial	0	AP	7.29	0
85	oval	450	no	medial	5	AP	17.13	0
85	oval	450	no	medial	6	AP	11.89	0
85	oval	450	no	medial	8	AP	19.03	0
85	oval	450	no	medial	10	AP	19.82	0
85	oval	450	no	medial	12.5	AP	15.54	0
85	oval	450	no	lateral	0	ML	13.32	0
85	oval	450	no	lateral	5	ML	9.99	0
85	oval	450	no	lateral	6	ML	10.78	0

85	oval	450	no	lateral	8	ML	12.69	0
85	oval	450	no	lateral	10	ML	15.22	0
85	oval	450	no	lateral	12.5	ML	9.51	0
42	oval	450	no	medial	0	AP	6.57	0
42	oval	450	no	medial	5	AP	8.61	0
42	oval	450	no	medial	6	AP	8.35	0
42	oval	450	no	medial	8	AP	7.08	0
42	oval	450	no	medial	10	AP	4.46	0
42	oval	450	no	medial	12.5	AP	6.44	0
42	oval	450	no	lateral	0	ML	6.31	0
42	oval	450	no	lateral	5	ML	8.99	0
42	oval	450	no	lateral	6	ML	8.61	0
42	oval	450	no	lateral	8	ML	6.57	9.69
42	oval	450	no	lateral	10	ML	5.42	35.54
42	oval	450	no	lateral	12.5	ML	5.99	42
43	oval	450	no	medial	0	AP	4.53	0
43	oval	450	no	medial	5	AP	5.04	0
43	oval	450	no	medial	6	AP	3.89	0
43	oval	450	no	medial	8	AP	3.95	0
43	oval	450	no	medial	10	AP	4.53	0
43	oval	450	no	medial	12.5	AP	4.78	0
43	oval	450	no	lateral	0	AP	6.18	0
43	oval	450	no	lateral	5	AP	8.99	0
43	oval	450	no	lateral	6	AP	9.56	4.85
43	oval	450	no	lateral	8	AP	7.01	14.54
43	oval	450	no	lateral	10	AP	7.78	24.23
43	oval	450	no	lateral	12.5	AP	4.65	25.85
44	oval	450	no	medial	0	AP	10.33	0
44	oval	450	no	medial	5	AP	9.37	0
44	oval	450	no	medial	6	AP	8.54	0
44	oval	450	no	medial	8	AP	9.31	0
44	oval	450	no	medial	10	AP	10.07	0
44	oval	450	no	medial	12.5	AP	9.75	0
44	oval	450	no	lateral	0	ML	4.78	0
44	oval	450	no	lateral	5	ML	1.59	0
44	oval	450	no	lateral	6	ML	1.47	0
44	oval	450	no	lateral	8	ML	1.91	0
44	oval	450	no	lateral	10	ML	2.3	0
44	oval	450	no	lateral	12.5	ML	4.59	0
45	oval	450	no	medial	0	AP	4.06	0
45	oval	450	no	medial	5	AP	4.99	0

45	oval	450	no	medial	6	AP	4.06	0
45	oval	450	no	medial	8	AP	2.82	0
45	oval	450	no	medial	10	AP	2.96	0
45	oval	450	no	medial	12.5	AP	3.89	0
45	oval	450	no	lateral	0	AP	7.36	0
45	oval	450	no	lateral	5	AP	9.23	0
45	oval	450	no	lateral	6	AP	5.08	0
45	oval	450	no	lateral	8	AP	7.28	0
45	oval	450	no	lateral	10	AP	3.72	16.15
45	oval	450	no	lateral	12.5	AP	7.28	58.15
46	oval	450	no	medial	0	ML	12.19	0
46	oval	450	no	medial	5	ML	11.7	0
46	oval	450	no	medial	6	ML	11.6	0
46	oval	450	no	medial	8	ML	14.05	0
46	oval	450	no	medial	10	ML	11.77	12.92
46	oval	450	no	medial	12.5	ML	11.43	37.15
46	oval	450	no	lateral	0	AP	10.58	0
46	oval	450	no	lateral	5	AP	10.07	0
46	oval	450	no	lateral	6	AP	9.65	0
46	oval	450	no	lateral	8	AP	9.4	0
46	oval	450	no	lateral	10	AP	9.4	0
46	oval	450	no	lateral	12.5	AP	5.59	12.92
47	oval	450	no	medial	0	AP	5.55	0
47	oval	450	no	medial	5	AP	6.82	0
47	oval	450	no	medial	6	AP	6.7	0
47	oval	450	no	medial	8	AP	7.36	0
47	oval	450	no	medial	10	AP	6.94	0
47	oval	450	no	medial	12.5	AP	4.71	22.62
47	oval	450	no	lateral	0	AP	6.52	0
47	oval	450	no	lateral	5	AP	8.87	0
47	oval	450	no	lateral	6	AP	9.71	0
47	oval	450	no	lateral	8	AP	8.81	0
47	oval	450	no	lateral	10	AP	6.09	25.85
47	oval	450	no	lateral	12.5	AP	4.46	38.77
48	oval	450	no	medial	0	AP	5.19	0
48	oval	450	no	medial	5	AP	7.42	0
48	oval	450	no	medial	6	AP	9.41	0
48	oval	450	no	medial	8	AP	8.87	0
48	oval	450	no	medial	10	AP	9.05	0
48	oval	450	no	medial	12.5	AP	5.85	11.31
48	oval	450	no	lateral	0	AP	7.66	0

48	oval	450	no	lateral	5	AP	8.87	0
48	oval	450	no	lateral	6	AP	8.75	0
48	oval	450	no	lateral	8	AP	8.27	0
48	oval	450	no	lateral	10	AP	8.63	0
48	oval	450	no	lateral	12.5	AP	4.4	9.69
81	oval	450	no	medial	0	AP	5.38	0
81	oval	450	no	medial	5	AP	9.27	0
81	oval	450	no	medial	6	AP	9.27	0
81	oval	450	no	medial	8	AP	10.18	0
81	oval	450	no	medial	10	AP	9.38	0
81	oval	450	no	medial	12.5	AP	8.92	0
81	oval	450	no	lateral	0	ML	8.35	0
81	oval	450	no	lateral	5	ML	9.38	0
81	oval	450	no	lateral	6	ML	6.75	0
81	oval	450	no	lateral	8	ML	6.75	0
81	oval	450	no	lateral	10	ML	7.66	0
81	oval	450	no	lateral	12.5	ML	9.84	0
50	oval	450	no	medial	0	ML	5.11	0
50	oval	450	no	medial	5	ML	6.14	0
50	oval	450	no	medial	6	ML	5.93	0
50	oval	450	no	medial	8	ML	7.45	0
50	oval	450	no	medial	10	ML	8	0
50	oval	450	no	medial	12.5	ML	7.04	0
50	oval	450	no	lateral	0	ML	5.24	0
50	oval	450	no	lateral	5	ML	6.9	0
50	oval	450	no	lateral	6	ML	6.83	0
50	oval	450	no	lateral	8	ML	6.9	0
50	oval	450	no	lateral	10	ML	5.31	0
50	oval	450	no	lateral	12.5	ML	4.83	0
51	oval	450	no	medial	0	AP	9.38	0
51	oval	450	no	medial	5	AP	10.49	0
51	oval	450	no	medial	6	AP	10.42	0
51	oval	450	no	medial	8	AP	9.04	0
51	oval	450	no	medial	10	AP	8.69	0
51	oval	450	no	medial	12.5	AP	7.18	0
51	oval	450	no	lateral	0	ML	6.42	0
51	oval	450	no	lateral	5	ML	6.83	0
51	oval	450	no	lateral	6	ML	7.18	0
51	oval	450	no	lateral	8	ML	7.73	0
51	oval	450	no	lateral	10	ML	5.73	14.54
51	oval	450	no	lateral	12.5	ML	4.48	24.23

52	oval	450	no	medial	0	ML	5.31	0
52	oval	450	no	medial	5	ML	8.07	0
52	oval	450	no	medial	6	ML	6.69	0
52	oval	450	no	medial	8	ML	4.9	0
52	oval	450	no	medial	10	ML	3.59	0
52	oval	450	no	medial	12.5	ML	2.21	0
52	oval	450	no	lateral	0	AP	5.73	0
52	oval	450	no	lateral	5	AP	4.69	0
52	oval	450	no	lateral	6	AP	5.45	0
52	oval	450	no	lateral	8	AP	7.73	0
52	oval	450	no	lateral	10	AP	6.35	3.23
52	oval	450	no	lateral	12.5	AP	3.04	21
53	oval	450	no	medial	0	ML	7.22	0
53	oval	450	no	medial	5	ML	7.08	0
53	oval	450	no	medial	6	ML	7.43	0
53	oval	450	no	medial	8	ML	8.62	0
53	oval	450	no	medial	10	ML	10.8	0
53	oval	450	no	medial	12.5	ML	8.48	29.08
53	oval	450	no	lateral	0	AP	7.08	0
53	oval	450	no	lateral	5	AP	8.62	0
53	oval	450	no	lateral	6	AP	8.41	0
53	oval	450	no	lateral	8	AP	8.2	0
53	oval	450	no	lateral	10	AP	8.2	0
53	oval	450	no	lateral	12.5	AP	6.31	14.54
54	oval	450	no	medial	0	AP	8.27	0
54	oval	450	no	medial	5	AP	8.69	0
54	oval	450	no	medial	6	AP	6.45	0
54	oval	450	no	medial	8	AP	5.89	0
54	oval	450	no	medial	10	AP	9.11	17.77
54	oval	450	no	medial	12.5	AP	7.08	17.77
54	oval	450	no	lateral	0	AP	6.87	0
54	oval	450	no	lateral	5	AP	6.03	0
54	oval	450	no	lateral	6	AP	4.56	0
54	oval	450	no	lateral	8	AP	7.36	0
54	oval	450	no	lateral	10	AP	5.54	17.77
54	oval	450	no	lateral	12.5	AP	5.26	21
55	oval	450	no	medial	0	ML	5.89	0
55	oval	450	no	medial	5	ML	5.26	0
55	oval	450	no	medial	6	ML	4.91	0
55	oval	450	no	medial	8	ML	6.8	0
55	oval	450	no	medial	10	ML	6.03	0

55	oval	450	no	medial	12.5	ML	5.75	0
55	oval	450	no	lateral	0	ML	6.59	0
55	oval	450	no	lateral	5	ML	5.68	0
55	oval	450	no	lateral	6	ML	6.38	0
55	oval	450	no	lateral	8	ML	5.05	0
55	oval	450	no	lateral	10	ML	6.31	0
55	oval	450	no	lateral	12.5	ML	6.1	0
56	oval	450	no	medial	0	ML	5.47	0
56	oval	450	no	medial	5	ML	5.89	0
56	oval	450	no	medial	6	ML	6.52	0
56	oval	450	no	medial	8	ML	4.35	0
56	oval	450	no	medial	10	ML	4.7	6.46
56	oval	450	no	medial	12.5	ML	4.98	14.54
56	oval	450	no	lateral	0	ML	3.58	0
56	oval	450	no	lateral	5	ML	4.63	0
56	oval	450	no	lateral	6	ML	6.03	0
56	oval	450	no	lateral	8	ML	6.03	0
56	oval	450	no	lateral	10	ML	6.1	0
56	oval	450	no	lateral	12.5	ML	6.31	0
57	oval	450	no	medial	0	ML	5.07	0
57	oval	450	no	medial	5	ML	5.72	0
57	oval	450	no	medial	6	ML	5.79	0
57	oval	450	no	medial	8	ML	6.4	0
57	oval	450	no	medial	10	ML	8.35	0
57	oval	450	no	medial	12.5	ML	7.07	0
57	oval	450	no	lateral	0	ML	8.58	0
57	oval	450	no	lateral	5	ML	7.37	0
57	oval	450	no	lateral	6	ML	6.55	0
57	oval	450	no	lateral	8	ML	7.52	0
57	oval	450	no	lateral	10	ML	3.91	17.77
57	oval	450	no	lateral	12.5	ML	5.57	37.15
58	oval	450	no	medial	0	ML	8.5	0
58	oval	450	no	medial	5	ML	8.28	0
58	oval	450	no	medial	6	ML	10.01	0
58	oval	450	no	medial	8	ML	8.5	0
58	oval	450	no	medial	10	ML	8.05	0
58	oval	450	no	medial	12.5	ML	4.89	22.62
58	oval	450	no	lateral	0	AP	6.02	0
58	oval	450	no	lateral	5	AP	5.64	0
58	oval	450	no	lateral	6	AP	4.51	0
58	oval	450	no	lateral	8	AP	6.4	0

58	oval	450	no	lateral	10	AP	8.8	0
58	oval	450	no	lateral	12.5	AP	9.86	12.92
59	oval	450	no	medial	0	ML	6.25	0
59	oval	450	no	medial	5	ML	5.64	0
59	oval	450	no	medial	6	ML	4.97	0
59	oval	450	no	medial	8	ML	7	0
59	oval	450	no	medial	10	ML	4.82	0
59	oval	450	no	medial	12.5	ML	5.87	0
59	oval	450	no	lateral	0	AP	9.56	0
59	oval	450	no	lateral	5	AP	8.95	0
59	oval	450	no	lateral	6	AP	9.48	0
59	oval	450	no	lateral	8	AP	11.74	0
59	oval	450	no	lateral	10	AP	11.51	0
59	oval	450	no	lateral	12.5	AP	10.16	0
60	oval	450	no	medial	0	ML	7.9	0
60	oval	450	no	medial	5	ML	9.03	0
60	oval	450	no	medial	6	ML	9.1	0
60	oval	450	no	medial	8	ML	9.56	0
60	oval	450	no	medial	10	ML	10.31	0
60	oval	450	no	medial	12.5	ML	6.32	25.85
60	oval	450	no	lateral	0	ML	5.49	0
60	oval	450	no	lateral	5	ML	3.46	0
60	oval	450	no	lateral	6	ML	3.46	0
60	oval	450	no	lateral	8	ML	4.82	0
60	oval	450	no	lateral	10	ML	7.67	0
60	oval	450	no	lateral	12.5	ML	7	0
61	oval	450	yes	medial	0	AP	3.03	0
61	oval	450	yes	medial	5	AP	3.77	0
61	oval	450	yes	medial	6	AP	3.47	0
61	oval	450	yes	medial	8	AP	3.99	0
61	oval	450	yes	medial	10	AP	4.58	0
61	oval	450	yes	medial	12.5	AP	4.41	0
61	oval	450	yes	lateral	0	ML	4.65	0
61	oval	450	yes	lateral	5	ML	4.95	0
61	oval	450	yes	lateral	6	ML	4.73	0
61	oval	450	yes	lateral	8	ML	5.76	0
61	oval	450	yes	lateral	10	ML	5.76	0
61	oval	450	yes	lateral	12.5	ML	7.02	0
62	oval	450	yes	medial	0	AP	2.73	0
62	oval	450	yes	medial	5	AP	3.18	0
62	oval	450	yes	medial	6	AP	3.18	0

62	oval	450	yes	medial	8	AP	3.69	0
62	oval	450	yes	medial	10	AP	3.1	0
62	oval	450	yes	medial	12.5	AP	2.81	12.92
62	oval	450	yes	lateral	0	AP	3.25	0
62	oval	450	yes	lateral	5	AP	3.4	0
62	oval	450	yes	lateral	6	AP	2.29	0
62	oval	450	yes	lateral	8	AP	2.73	0
62	oval	450	yes	lateral	10	AP	3.47	0
62	oval	450	yes	lateral	12.5	AP	3.92	0
63	oval	450	yes	medial	0	AP	3.72	0
63	oval	450	yes	medial	5	AP	4.28	0
63	oval	450	yes	medial	6	AP	4.2	0
63	oval	450	yes	medial	8	AP	4.69	0
63	oval	450	yes	medial	10	AP	3.15	14.54
63	oval	450	yes	medial	12.5	AP	4.04	29.08
63	oval	450	yes	lateral	0	ML	4.53	0
63	oval	450	yes	lateral	5	ML	4.69	0
63	oval	450	yes	lateral	6	ML	5.09	0
63	oval	450	yes	lateral	8	ML	3.96	0
63	oval	450	yes	lateral	10	ML	5.82	0
63	oval	450	yes	lateral	12.5	ML	5.33	0
84	oval	450	yes	medial	0	AP	3.45	0
84	oval	450	yes	medial	5	AP	3.58	0
84	oval	450	yes	medial	6	AP	3.72	0
84	oval	450	yes	medial	8	AP	3.45	0
84	oval	450	yes	medial	10	AP	3.72	0
84	oval	450	yes	medial	12.5	AP	10.09	0
84	oval	450	yes	lateral	0	AP	4.91	0
84	oval	450	yes	lateral	5	AP	5.04	0
84	oval	450	yes	lateral	6	AP	5.84	0
84	oval	450	yes	lateral	8	AP	5.84	0
84	oval	450	yes	lateral	10	AP	5.58	0
84	oval	450	yes	lateral	12.5	AP	6.11	0
65	oval	450	yes	medial	0	AP	2.38	0
65	oval	450	yes	medial	5	AP	3.66	0
65	oval	450	yes	medial	6	AP	4.51	0
65	oval	450	yes	medial	8	AP	4.71	0
65	oval	450	yes	medial	10	AP	4.78	45.23
65	oval	450	yes	medial	12.5	AP	3.53	58.15
65	oval	450	yes	lateral	0	AP	2.75	0
65	oval	450	yes	lateral	5	AP	6.22	0

65	oval	450	yes	lateral	6	AP	8.77	0
65	oval	450	yes	lateral	8	AP	2.68	0
65	oval	450	yes	lateral	10	AP	3.53	9.69
65	oval	450	yes	lateral	12.5	AP	5.82	14.54
66	oval	450	yes	medial	0	ML	2.79	0
66	oval	450	yes	medial	5	ML	5.79	0
66	oval	450	yes	medial	6	ML	4.97	0
66	oval	450	yes	medial	8	ML	5.31	0
66	oval	450	yes	medial	10	ML	4.7	0
66	oval	450	yes	medial	12.5	ML	4.29	0
66	oval	450	yes	lateral	0	AP	2.43	0
66	oval	450	yes	lateral	5	AP	5.59	0
66	oval	450	yes	lateral	6	AP	5.59	0
66	oval	450	yes	lateral	8	AP	6.88	0
66	oval	450	yes	lateral	10	AP	5.93	0
66	oval	450	yes	lateral	12.5	AP	3.07	24.23
67	oval	450	yes	medial	0	AP	2.99	0
67	oval	450	yes	medial	5	AP	3.52	0
67	oval	450	yes	medial	6	AP	3.81	0
67	oval	450	yes	medial	8	AP	4.11	0
67	oval	450	yes	medial	10	AP	4.04	0
67	oval	450	yes	medial	12.5	AP	3.29	0
67	oval	450	yes	lateral	0	AP	2.77	0
67	oval	450	yes	lateral	5	AP	3.44	0
67	oval	450	yes	lateral	6	AP	3.81	0
67	oval	450	yes	lateral	8	AP	3.96	0
67	oval	450	yes	lateral	10	AP	4.86	0
67	oval	450	yes	lateral	12.5	AP	6.81	0
68	oval	450	yes	medial	0	AP	3.05	0
68	oval	450	yes	medial	5	AP	4.97	0
68	oval	450	yes	medial	6	AP	4.83	0
68	oval	450	yes	medial	8	AP	5.47	0
68	oval	450	yes	medial	10	AP	6.32	0
68	oval	450	yes	medial	12.5	AP	7.81	0
68	oval	450	yes	lateral	0	ML	2.27	0
68	oval	450	yes	lateral	5	ML	4.83	0
68	oval	450	yes	lateral	6	ML	4.55	0
68	oval	450	yes	lateral	8	ML	2.91	0
68	oval	450	yes	lateral	10	ML	3.27	0
68	oval	450	yes	lateral	12.5	ML	2.98	0
69	oval	450	yes	medial	0	ML	3.86	0

69	oval	450	yes	medial	5	ML	6.24	0
69	oval	450	yes	medial	6	ML	6.24	0
69	oval	450	yes	medial	8	ML	6.73	0
69	oval	450	yes	medial	10	ML	6.38	0
69	oval	450	yes	medial	12.5	ML	5.82	4.85
69	oval	450	yes	lateral	0	ML	4.07	0
69	oval	450	yes	lateral	5	ML	3.3	0
69	oval	450	yes	lateral	6	ML	3.65	0
69	oval	450	yes	lateral	8	ML	4.14	0
69	oval	450	yes	lateral	10	ML	4.21	11.31
69	oval	450	yes	lateral	12.5	ML	4.42	27.46
70	oval	450	yes	medial	0	ML	2.38	0
70	oval	450	yes	medial	5	ML	2.46	0
70	oval	450	yes	medial	6	ML	2.54	0
70	oval	450	yes	medial	8	ML	2.54	0
70	oval	450	yes	medial	10	ML	3.03	0
70	oval	450	yes	medial	12.5	ML	3.61	0
70	oval	450	yes	lateral	0	AP	4.26	0
70	oval	450	yes	lateral	5	AP	4.26	0
70	oval	450	yes	lateral	6	AP	3.69	0
70	oval	450	yes	lateral	8	AP	5.17	0
70	oval	450	yes	lateral	10	AP	4.59	0
70	oval	450	yes	lateral	12.5	AP	4.76	0
71	oval	450	yes	medial	0	ML	3.44	0
71	oval	450	yes	medial	5	ML	2.51	0
71	oval	450	yes	medial	6	ML	2.94	0
71	oval	450	yes	medial	8	ML	2.8	0
71	oval	450	yes	medial	10	ML	3.15	0
71	oval	450	yes	medial	12.5	ML	3.58	0
71	oval	450	yes	lateral	0	ML	5.66	0
71	oval	450	yes	lateral	5	ML	5.73	0
71	oval	450	yes	lateral	6	ML	4.66	0
71	oval	450	yes	lateral	8	ML	1.79	0
71	oval	450	yes	lateral	10	ML	2.29	0
71	oval	450	yes	lateral	12.5	ML	2.51	0
72	oval	450	yes	medial	0	ML	3.19	0
72	oval	450	yes	medial	5	ML	3.69	0
72	oval	450	yes	medial	6	ML	3.36	0
72	oval	450	yes	medial	8	ML	3.85	0
72	oval	450	yes	medial	10	ML	4.1	0
72	oval	450	yes	medial	12.5	ML	3.85	0

72	oval	450	yes	lateral	0	ML	9.01	0
72	oval	450	yes	lateral	5	ML	8.68	0
72	oval	450	yes	lateral	6	ML	8.35	0
72	oval	450	yes	lateral	8	ML	8.44	0
72	oval	450	yes	lateral	10	ML	7.94	0
72	oval	450	yes	lateral	12.5	ML	8.52	0
73	oval	450	yes	medial	0	AP	4.87	0
73	oval	450	yes	medial	5	AP	6.09	0
73	oval	450	yes	medial	6	AP	6.35	0
73	oval	450	yes	medial	8	AP	5.48	0
73	oval	450	yes	medial	10	AP	10.87	0
73	oval	450	yes	medial	12.5	AP	12.61	3.23
73	oval	450	yes	lateral	0	AP	4.35	0
73	oval	450	yes	lateral	5	AP	3.48	0
73	oval	450	yes	lateral	6	AP	3.39	0
73	oval	450	yes	lateral	8	AP	3.3	0
73	oval	450	yes	lateral	10	AP	3.65	0
73	oval	450	yes	lateral	12.5	AP	6.52	0
74	oval	450	yes	medial	0	ML	3.15	0
74	oval	450	yes	medial	5	ML	3.43	0
74	oval	450	yes	medial	6	ML	3.82	0
74	oval	450	yes	medial	8	ML	4.48	0
74	oval	450	yes	medial	10	ML	4.96	0
74	oval	450	yes	medial	12.5	ML	5.06	0
74	oval	450	yes	lateral	0	ML	3.91	0
74	oval	450	yes	lateral	5	ML	3.05	0
74	oval	450	yes	lateral	6	ML	2.86	0
74	oval	450	yes	lateral	8	ML	2.96	0
74	oval	450	yes	lateral	10	ML	3.53	0
74	oval	450	yes	lateral	12.5	ML	3.82	0
75	oval	450	yes	medial	0	ML	3.17	0
75	oval	450	yes	medial	5	ML	3.86	0
75	oval	450	yes	medial	6	ML	3.86	0
75	oval	450	yes	medial	8	ML	4.09	0
75	oval	450	yes	medial	10	ML	4.86	0
75	oval	450	yes	medial	12.5	ML	4.49	0
75	oval	450	yes	lateral	0	AP	5.02	0
75	oval	450	yes	lateral	5	AP	4.01	0
75	oval	450	yes	lateral	6	AP	4.48	0
75	oval	450	yes	lateral	8	AP	2.39	0
75	oval	450	yes	lateral	10	AP	3.4	0

75	oval	450	yes	lateral	12.5	AP	3.32	6.46
76	oval	450	yes	medial	0	ML	4.49	0
76	oval	450	yes	medial	5	ML	5.03	0
76	oval	450	yes	medial	6	ML	5.39	0
76	oval	450	yes	medial	8	ML	4.67	0
76	oval	450	yes	medial	10	ML	4.67	0
76	oval	450	yes	medial	12.5	ML	6.29	0
76	oval	450	yes	lateral	0	AP	8.99	0
76	oval	450	yes	lateral	5	AP	9.17	0
76	oval	450	yes	lateral	6	AP	7.19	0
76	oval	450	yes	lateral	8	AP	6.11	0
76	oval	450	yes	lateral	10	AP	7.01	0
76	oval	450	yes	lateral	12.5	AP	5.57	0
77	oval	450	yes	medial	0	AP	4.24	0
77	oval	450	yes	medial	5	AP	3.77	0
77	oval	450	yes	medial	6	AP	3.77	0
77	oval	450	yes	medial	8	AP	3.3	0
77	oval	450	yes	medial	10	AP	3.54	0
77	oval	450	yes	medial	12.5	AP	3.98	0
77	oval	450	yes	lateral	0	ML	9.67	0
77	oval	450	yes	lateral	5	ML	9.43	0
77	oval	450	yes	lateral	6	ML	6.6	0
77	oval	450	yes	lateral	8	ML	6.95	0
77	oval	450	yes	lateral	10	ML	8.72	0
77	oval	450	yes	lateral	12.5	ML	9.55	0
78	oval	450	yes	medial	0	AP	4.26	0
78	oval	450	yes	medial	5	AP	4.92	0
78	oval	450	yes	medial	6	AP	4.92	0
78	oval	450	yes	medial	8	AP	6.56	0
78	oval	450	yes	medial	10	AP	5.58	0
78	oval	450	yes	medial	12.5	AP	5.58	0
78	oval	450	yes	lateral	0	ML	7.38	0
78	oval	450	yes	lateral	5	ML	7.05	0
78	oval	450	yes	lateral	6	ML	5.74	0
78	oval	450	yes	lateral	8	ML	4.92	0
78	oval	450	yes	lateral	10	ML	5.58	0
78	oval	450	yes	lateral	12.5	ML	7.05	0
79	oval	450	yes	medial	0	ML	2.85	0
79	oval	450	yes	medial	5	ML	3.54	0
79	oval	450	yes	medial	6	ML	3.28	0
79	oval	450	yes	medial	8	ML	3.45	0

79	oval	450	yes	medial	10	ML	3.45	0
79	oval	450	yes	medial	12.5	ML	3.71	4.85
79	oval	450	yes	lateral	0	AP	6.13	0
79	oval	450	yes	lateral	5	AP	6.39	0
79	oval	450	yes	lateral	6	AP	6.48	0
79	oval	450	yes	lateral	8	AP	8.2	0
79	oval	450	yes	lateral	10	AP	7.77	0
79	oval	450	yes	lateral	12.5	AP	10.1	0
80	oval	450	yes	medial	0	ML	5.35	0
80	oval	450	yes	medial	5	ML	5.53	0
80	oval	450	yes	medial	6	ML	5.87	0
80	oval	450	yes	medial	8	ML	5.7	0
80	oval	450	yes	medial	10	ML	7.25	0
80	oval	450	yes	medial	12.5	ML	6.39	0
80	oval	450	yes	lateral	0	ML	4.32	0
80	oval	450	yes	lateral	5	ML	5.01	0
80	oval	450	yes	lateral	6	ML	7.08	0
80	oval	450	yes	lateral	8	ML	5.01	0
80	oval	450	yes	lateral	10	ML	5.7	0
80	oval	450	yes	lateral	12.5	ML	10.36	30.69
90	circle	450	yes	medial	0	none	2.56	0
90	circle	450	yes	medial	5	none	2.68	0
90	circle	450	yes	medial	6	none	2.41	0
90	circle	450	yes	medial	8	none	2.41	0
90	circle	450	yes	medial	10	none	2.37	0
90	circle	450	yes	medial	12.5	none	2.6	0
90	circle	450	yes	lateral	0	none	2.72	0
90	circle	450	yes	lateral	5	none	2.76	0
90	circle	450	yes	lateral	6	none	3.34	0
90	circle	450	yes	lateral	8	none	3.03	0
90	circle	450	yes	lateral	10	none	3.42	0
90	circle	450	yes	lateral	12.5	none	3.57	0
91	circle	450	yes	medial	0	none	1.7	0
91	circle	450	yes	medial	5	none	2.15	0
91	circle	450	yes	medial	6	none	2.01	0
91	circle	450	yes	medial	8	none	2.14	0
91	circle	450	yes	medial	10	none	1.98	0
91	circle	450	yes	medial	12.5	none	2.07	0
91	circle	450	yes	lateral	0	none	2.01	0
91	circle	450	yes	lateral	5	none	1.44	0
91	circle	450	yes	lateral	6	none	1.73	0

91	circle	450	yes	lateral	8	none	1.68	0
91	circle	450	yes	lateral	10	none	1.75	0
91	circle	450	yes	lateral	12.5	none	1.57	0
92	circle	450	yes	medial	0	none	1.81	0
92	circle	450	yes	medial	5	none	2.16	0
92	circle	450	yes	medial	6	none	2.29	0
92	circle	450	yes	medial	8	none	2.34	0
92	circle	450	yes	medial	10	none	2.37	0
92	circle	450	yes	medial	12.5	none	2.8	0
92	circle	450	yes	lateral	0	none	2.72	0
92	circle	450	yes	lateral	5	none	2.17	0
92	circle	450	yes	lateral	6	none	2.06	0
92	circle	450	yes	lateral	8	none	1.81	0
92	circle	450	yes	lateral	10	none	2.29	0
92	circle	450	yes	lateral	12.5	none	2.37	0
93	circle	450	yes	medial	0	none	2.13	0
93	circle	450	yes	medial	5	none	1.88	0
93	circle	450	yes	medial	6	none	1.93	0
93	circle	450	yes	medial	8	none	2.04	0
93	circle	450	yes	medial	10	none	2.02	0
93	circle	450	yes	medial	12.5	none	2.75	0
93	circle	450	yes	lateral	0	none	4.22	0
93	circle	450	yes	lateral	5	none	4.75	0
93	circle	450	yes	lateral	6	none	4.66	0
93	circle	450	yes	lateral	8	none	5.08	0
93	circle	450	yes	lateral	10	none	4.5	0
93	circle	450	yes	lateral	12.5	none	2.72	0
94	circle	450	yes	medial	0	none	1.43	0
94	circle	450	yes	medial	5	none	1.39	0
94	circle	450	yes	medial	6	none	2.52	0
94	circle	450	yes	medial	8	none	1.64	0
94	circle	450	yes	medial	10	none	1.83	0
94	circle	450	yes	medial	12.5	none	2.88	0
94	circle	450	yes	lateral	0	none	1.74	0
94	circle	450	yes	lateral	5	none	2.83	0
94	circle	450	yes	lateral	6	none	2.56	0
94	circle	450	yes	lateral	8	none	4.03	0
94	circle	450	yes	lateral	10	none	3.76	0
94	circle	450	yes	lateral	12.5	none	5.22	0
95	circle	450	yes	medial	0	none	1.75	0
95	circle	450	yes	medial	5	none	1.9	0

95	circle	450	yes	medial	6	none	2.17	0
95	circle	450	yes	medial	8	none	2.27	0
95	circle	450	yes	medial	10	none	2.42	0
95	circle	450	yes	medial	12.5	none	2.54	0
95	circle	450	yes	lateral	0	none	1.18	0
95	circle	450	yes	lateral	5	none	1.3	0
95	circle	450	yes	lateral	6	none	1.21	0
95	circle	450	yes	lateral	8	none	1.1	0
95	circle	450	yes	lateral	10	none	0.93	0
95	circle	450	yes	lateral	12.5	none	1.11	0
96	circle	450	yes	medial	0	none	1.17	0
96	circle	450	yes	medial	5	none	1.24	0
96	circle	450	yes	medial	6	none	1.61	0
96	circle	450	yes	medial	8	none	1.57	0
96	circle	450	yes	medial	10	none	1.62	0
96	circle	450	yes	medial	12.5	none	1.73	0
96	circle	450	yes	lateral	0	none	3.16	0
96	circle	450	yes	lateral	5	none	4.34	0
96	circle	450	yes	lateral	6	none	3.08	0
96	circle	450	yes	lateral	8	none	2.65	0
96	circle	450	yes	lateral	10	none	1.89	0
96	circle	450	yes	lateral	12.5	none	1.8	0
97	circle	450	yes	medial	0	none	2.32	0
97	circle	450	yes	medial	5	none	1.83	0
97	circle	450	yes	medial	6	none	2.61	0
97	circle	450	yes	medial	8	none	2.26	0
97	circle	450	yes	medial	10	none	2.11	0
97	circle	450	yes	medial	12.5	none	2.11	0
97	circle	450	yes	lateral	0	none	1.57	0
97	circle	450	yes	lateral	5	none	1.55	0
97	circle	450	yes	lateral	6	none	1.38	0
97	circle	450	yes	lateral	8	none	1.54	0
97	circle	450	yes	lateral	10	none	1.7	0
97	circle	450	yes	lateral	12.5	none	2.14	0
98	circle	450	yes	medial	0	none	2.14	0
98	circle	450	yes	medial	5	none	1.96	0
98	circle	450	yes	medial	6	none	2.65	0
98	circle	450	yes	medial	8	none	1.89	0
98	circle	450	yes	medial	10	none	1.38	0
98	circle	450	yes	medial	12.5	none	1.14	0
98	circle	450	yes	lateral	0	none	1.54	0

98	circle	450	yes	lateral	5	none	1.75	0
98	circle	450	yes	lateral	6	none	1.66	0
98	circle	450	yes	lateral	8	none	1.83	0
98	circle	450	yes	lateral	10	none	1.79	0
98	circle	450	yes	lateral	12.5	none	2.11	0
99	circle	450	yes	medial	0	none	1.9	0
99	circle	450	yes	medial	5	none	2.13	0
99	circle	450	yes	medial	6	none	2.18	0
99	circle	450	yes	medial	8	none	2.63	0
99	circle	450	yes	medial	10	none	2.73	0
99	circle	450	yes	medial	12.5	none	2.72	0
99	circle	450	yes	lateral	0	none	3.16	0
99	circle	450	yes	lateral	5	none	4.81	0
99	circle	450	yes	lateral	6	none	4.71	0
99	circle	450	yes	lateral	8	none	3.49	0
99	circle	450	yes	lateral	10	none	4.07	0
99	circle	450	yes	lateral	12.5	none	2.82	0
100	circle	450	no	medial	0	none	5.23	0
100	circle	450	no	medial	5	none	5.65	0
100	circle	450	no	medial	6	none	6.16	0
100	circle	450	no	medial	8	none	5.85	0
100	circle	450	no	medial	10	none	7.38	0
100	circle	450	no	medial	12.5	none	8.24	0
100	circle	450	no	lateral	0	none	3.31	0
100	circle	450	no	lateral	5	none	2.41	0
100	circle	450	no	lateral	6	none	0	0
100	circle	450	no	lateral	8	none	0	0
100	circle	450	no	lateral	10	none	0	0
100	circle	450	no	lateral	12.5	none	0	0
101	circle	450	no	medial	0	none	8.43	0
101	circle	450	no	medial	5	none	8.95	0
101	circle	450	no	medial	6	none	9.15	0
101	circle	450	no	medial	8	none	10.14	0
101	circle	450	no	medial	10	none	10.06	0
101	circle	450	no	medial	12.5	none	7.63	27.46
101	circle	450	no	lateral	0	none	4.77	0
101	circle	450	no	lateral	5	none	4.97	0
101	circle	450	no	lateral	6	none	5.15	0
101	circle	450	no	lateral	8	none	3.63	0
101	circle	450	no	lateral	10	none	5.05	0
101	circle	450	no	lateral	12.5	none	5.15	0

102	circle	450	no	medial	0	none	4.45	0
102	circle	450	no	medial	5	none	3.88	0
102	circle	450	no	medial	6	none	4.19	0
102	circle	450	no	medial	8	none	4.62	0
102	circle	450	no	medial	10	none	6.19	0
102	circle	450	no	medial	12.5	none	6.35	0
102	circle	450	no	lateral	0	none	7.06	0
102	circle	450	no	lateral	5	none	7.06	0
102	circle	450	no	lateral	6	none	6.63	0
102	circle	450	no	lateral	8	none	6.17	0
102	circle	450	no	lateral	10	none	5.66	0
102	circle	450	no	lateral	12.5	none	5.72	0
103	circle	450	no	medial	0	none	4.38	0
103	circle	450	no	medial	5	none	6.41	0
103	circle	450	no	medial	6	none	6.49	0
103	circle	450	no	medial	8	none	5.42	0
103	circle	450	no	medial	10	none	3.65	0
103	circle	450	no	medial	12.5	none	3.73	0
103	circle	450	no	lateral	0	none	9.36	0
103	circle	450	no	lateral	5	none	9.84	0
103	circle	450	no	lateral	6	none	9.63	0
103	circle	450	no	lateral	8	none	9.84	0
103	circle	450	no	lateral	10	none	10.27	0
103	circle	450	no	lateral	12.5	none	8.63	42
104	circle	450	no	medial	0	none	4.29	0
104	circle	450	no	medial	5	none	5.15	0
104	circle	450	no	medial	6	none	4.88	0
104	circle	450	no	medial	8	none	5.32	0
104	circle	450	no	medial	10	none	5.47	0
104	circle	450	no	medial	12.5	none	6.42	0
104	circle	450	no	lateral	0	none	5.08	0
104	circle	450	no	lateral	5	none	4.57	0
104	circle	450	no	lateral	6	none	4.74	0
104	circle	450	no	lateral	8	none	4.88	0
104	circle	450	no	lateral	10	none	6.34	6.46
104	circle	450	no	lateral	12.5	none	6.25	8.08
105	circle	450	no	medial	0	none	6.21	0
105	circle	450	no	medial	5	none	7.26	0
105	circle	450	no	medial	6	none	6.94	0
105	circle	450	no	medial	8	none	8.86	0
105	circle	450	no	medial	10	none	10.15	0

105	circle	450	no	medial	12.5	none	6.97	0
105	circle	450	no	lateral	0	none	8.91	0
105	circle	450	no	lateral	5	none	10.96	0
105	circle	450	no	lateral	6	none	10.61	0
105	circle	450	no	lateral	8	none	10.64	0
105	circle	450	no	lateral	10	none	12.04	3.23
105	circle	450	no	lateral	12.5	none	11.21	11.31
106	circle	450	no	medial	0	none	5.83	0
106	circle	450	no	medial	5	none	7.92	0
106	circle	450	no	medial	6	none	7.75	0
106	circle	450	no	medial	8	none	8.41	0
106	circle	450	no	medial	10	none	5.59	0
106	circle	450	no	medial	12.5	none	5.03	0
106	circle	450	no	lateral	0	none	7.34	0
106	circle	450	no	lateral	5	none	6.54	0
106	circle	450	no	lateral	6	none	6.78	0
106	circle	450	no	lateral	8	none	6.15	0
106	circle	450	no	lateral	10	none	5.64	27.46
106	circle	450	no	lateral	12.5	none	7.78	0
107	circle	450	no	medial	0	none	6.11	0
107	circle	450	no	medial	5	none	6.58	0
107	circle	450	no	medial	6	none	6.41	0
107	circle	450	no	medial	8	none	6.56	0
107	circle	450	no	medial	10	none	4.74	0
107	circle	450	no	medial	12.5	none	4.89	0
107	circle	450	no	lateral	0	none	3.95	0
107	circle	450	no	lateral	5	none	5	0
107	circle	450	no	lateral	6	none	5.17	0
107	circle	450	no	lateral	8	none	5.89	0
107	circle	450	no	lateral	10	none	6.39	0
107	circle	450	no	lateral	12.5	none	6.96	0
108	circle	450	no	medial	0	none	4	0
108	circle	450	no	medial	5	none	5.55	0
108	circle	450	no	medial	6	none	5.82	0
108	circle	450	no	medial	8	none	6.42	0
108	circle	450	no	medial	10	none	5.8	0
108	circle	450	no	medial	12.5	none	6.72	0
108	circle	450	no	lateral	0	none	9.14	0
108	circle	450	no	lateral	5	none	7.83	0
108	circle	450	no	lateral	6	none	7.31	0
108	circle	450	no	lateral	8	none	8.02	0

108	circle	450	no	lateral	10	none	7.54	0
108	circle	450	no	lateral	12.5	none	8.22	0
109	circle	450	no	medial	0	none	4.86	0
109	circle	450	no	medial	5	none	5.73	0
109	circle	450	no	medial	6	none	5.69	0
109	circle	450	no	medial	8	none	5.86	0
109	circle	450	no	medial	10	none	5.01	0
109	circle	450	no	medial	12.5	none	4.84	0
109	circle	450	no	lateral	0	none	5.84	0
109	circle	450	no	lateral	5	none	5.57	0
109	circle	450	no	lateral	6	none	5.67	0
109	circle	450	no	lateral	8	none	5.78	0
109	circle	450	no	lateral	10	none	7.55	0
109	circle	450	no	lateral	12.5	none	7.32	0
110	circle	900	no	medial	0	none	6.9	0
110	circle	900	no	medial	5	none	7.45	0
110	circle	900	no	medial	6	none	7.21	0
110	circle	900	no	medial	8	none	7.64	0
110	circle	900	no	medial	10	none	7.76	0
110	circle	900	no	medial	12.5	none	8.84	0
110	circle	900	no	lateral	0	none	8.72	0
110	circle	900	no	lateral	5	none	9.2	0
110	circle	900	no	lateral	6	none	9.14	0
110	circle	900	no	lateral	8	none	9.62	0
110	circle	900	no	lateral	10	none	10.33	0
110	circle	900	no	lateral	12.5	none	10.33	8.08
111	circle	900	no	medial	0	none	7.24	0
111	circle	900	no	medial	5	none	8.08	0
111	circle	900	no	medial	6	none	7.66	0
111	circle	900	no	medial	8	none	9.4	0
111	circle	900	no	medial	10	none	10.82	0
111	circle	900	no	medial	12.5	none	11.98	0
111	circle	900	no	lateral	0	none	11.81	0
111	circle	900	no	lateral	5	none	12.18	0
111	circle	900	no	lateral	6	none	12.16	0
111	circle	900	no	lateral	8	none	11.58	0
111	circle	900	no	lateral	10	none	12.53	0
111	circle	900	no	lateral	12.5	none	10.25	19.38
112	circle	900	no	medial	0	none	7.17	0
112	circle	900	no	medial	5	none	6.4	0
112	circle	900	no	medial	6	none	6.2	0

112	circle	900	no	medial	8	none	6.62	0
112	circle	900	no	medial	10	none	7.87	0
112	circle	900	no	medial	12.5	none	6.86	0
112	circle	900	no	lateral	0	none	11.7	0
112	circle	900	no	lateral	5	none	11.44	0
112	circle	900	no	lateral	6	none	12.36	0
112	circle	900	no	lateral	8	none	11.7	0
112	circle	900	no	lateral	10	none	11.83	0
112	circle	900	no	lateral	12.5	none	9.53	0
113	circle	900	no	medial	0	none	15.36	0
113	circle	900	no	medial	5	none	18.91	0
113	circle	900	no	medial	6	none	18.54	0
113	circle	900	no	medial	8	none	15.87	0
113	circle	900	no	medial	10	none	15.89	0
113	circle	900	no	medial	12.5	none	16.35	0
113	circle	900	no	lateral	0	none	15.54	0
113	circle	900	no	lateral	5	none	21.41	0
113	circle	900	no	lateral	6	none	21.6	0
113	circle	900	no	lateral	8	none	20.61	0
113	circle	900	no	lateral	10	none	20.91	0
113	circle	900	no	lateral	12.5	none	21.59	3.23
114	circle	900	no	medial	0	none	12.36	0
114	circle	900	no	medial	5	none	12.84	0
114	circle	900	no	medial	6	none	12.16	0
114	circle	900	no	medial	8	none	11.97	0
114	circle	900	no	medial	10	none	11.88	0
114	circle	900	no	medial	12.5	none	10.35	0
114	circle	900	no	lateral	0	none	9.6	0
114	circle	900	no	lateral	5	none	11.52	0
114	circle	900	no	lateral	6	none	11.83	0
114	circle	900	no	lateral	8	none	13.99	0
114	circle	900	no	lateral	10	none	11.1	0
114	circle	900	no	lateral	12.5	none	7.41	27.46
115	circle	900	no	medial	0	none	9.57	0
115	circle	900	no	medial	5	none	10.27	0
115	circle	900	no	medial	6	none	9.68	0
115	circle	900	no	medial	8	none	12.39	0
115	circle	900	no	medial	10	none	10.64	0
115	circle	900	no	medial	12.5	none	8.45	0
115	circle	900	no	lateral	0	none	7.57	0
115	circle	900	no	lateral	5	none	5.22	0

115	circle	900	no	lateral	6	none	6.01	0
115	circle	900	no	lateral	8	none	7.26	0
115	circle	900	no	lateral	10	none	6.94	0
115	circle	900	no	lateral	12.5	none	6.94	0
116	circle	900	no	medial	0	none	9.29	0
116	circle	900	no	medial	5	none	8.26	0
116	circle	900	no	medial	6	none	8.26	0
116	circle	900	no	medial	8	none	8.54	0
116	circle	900	no	medial	10	none	9.68	0
116	circle	900	no	medial	12.5	none	10.25	0
116	circle	900	no	lateral	0	none	9.2	0
116	circle	900	no	lateral	5	none	9.77	0
116	circle	900	no	lateral	6	none	9.87	0
116	circle	900	no	lateral	8	none	11.05	0
116	circle	900	no	lateral	10	none	10.38	0
116	circle	900	no	lateral	12.5	none	6.74	42
117	circle	900	no	medial	0	none	5.79	0
117	circle	900	no	medial	5	none	6.71	0
117	circle	900	no	medial	6	none	6.88	0
117	circle	900	no	medial	8	none	8.1	0
117	circle	900	no	medial	10	none	9.11	0
117	circle	900	no	medial	12.5	none	9.34	3.23
117	circle	900	no	lateral	0	none	10.15	0
117	circle	900	no	lateral	5	none	9.87	0
117	circle	900	no	lateral	6	none	10.15	0
117	circle	900	no	lateral	8	none	12.4	0
117	circle	900	no	lateral	10	none	9.97	0
117	circle	900	no	lateral	12.5	none	12.12	9.69
118	circle	900	no	medial	0	none	5.07	0
118	circle	900	no	medial	5	none	5.53	0
118	circle	900	no	medial	6	none	6.58	0
118	circle	900	no	medial	8	none	5.46	0
118	circle	900	no	medial	10	none	5.53	0
118	circle	900	no	medial	12.5	none	5.33	0
118	circle	900	no	lateral	0	none	7.1	0
118	circle	900	no	lateral	5	none	7.68	0
118	circle	900	no	lateral	6	none	8.72	0
118	circle	900	no	lateral	8	none	9.62	0
118	circle	900	no	lateral	10	none	7.49	0
118	circle	900	no	lateral	12.5	none	8.58	4.85
119	circle	900	yes	medial	0	none	2.33	0

119	circle	900	yes	medial	5	none	2.32	0
119	circle	900	yes	medial	6	none	2.33	0
119	circle	900	yes	medial	8	none	2.34	0
119	circle	900	yes	medial	10	none	2.39	0
119	circle	900	yes	medial	12.5	none	2.43	0
119	circle	900	yes	lateral	0	none	2.35	0
119	circle	900	yes	lateral	5	none	2.36	0
119	circle	900	yes	lateral	6	none	2.3	0
119	circle	900	yes	lateral	8	none	2.37	0
119	circle	900	yes	lateral	10	none	2.27	0
119	circle	900	yes	lateral	12.5	none	2.27	0
120	circle	900	yes	medial	0	none	3.73	0
120	circle	900	yes	medial	5	none	4.19	0
120	circle	900	yes	medial	6	none	4.09	0
120	circle	900	yes	medial	8	none	4.04	0
120	circle	900	yes	medial	10	none	3.99	0
120	circle	900	yes	medial	12.5	none	3.93	0
120	circle	900	yes	lateral	0	none	5.16	0
120	circle	900	yes	lateral	5	none	4.04	0
120	circle	900	yes	lateral	6	none	4.24	0
120	circle	900	yes	lateral	8	none	3.72	0
120	circle	900	yes	lateral	10	none	3.64	0
120	circle	900	yes	lateral	12.5	none	3.88	0
121	circle	900	yes	medial	0	none	2.35	0
121	circle	900	yes	medial	5	none	2.45	0
121	circle	900	yes	medial	6	none	2.48	0
121	circle	900	yes	medial	8	none	2.59	0
121	circle	900	yes	medial	10	none	2.67	0
121	circle	900	yes	medial	12.5	none	2.91	0
121	circle	900	yes	lateral	0	none	2.58	0
121	circle	900	yes	lateral	5	none	2.59	0
121	circle	900	yes	lateral	6	none	2.62	0
121	circle	900	yes	lateral	8	none	2.57	0
121	circle	900	yes	lateral	10	none	2.71	0
121	circle	900	yes	lateral	12.5	none	2.69	0
122	circle	900	yes	medial	0	none	2.73	0
122	circle	900	yes	medial	5	none	2.93	0
122	circle	900	yes	medial	6	none	2.86	0
122	circle	900	yes	medial	8	none	2.86	0
122	circle	900	yes	medial	10	none	3.84	0
122	circle	900	yes	medial	12.5	none	4.23	0

122	circle	900	yes	lateral	0	none	3.9	0
122	circle	900	yes	lateral	5	none	4.94	0
122	circle	900	yes	lateral	6	none	5.2	0
122	circle	900	yes	lateral	8	none	5.85	0
122	circle	900	yes	lateral	10	none	5.92	0
122	circle	900	yes	lateral	12.5	none	5.72	0
123	circle	900	yes	medial	0	none	2.87	0
123	circle	900	yes	medial	5	none	2.98	0
123	circle	900	yes	medial	6	none	2.99	0
123	circle	900	yes	medial	8	none	3.62	0
123	circle	900	yes	medial	10	none	3.66	0
123	circle	900	yes	medial	12.5	none	4.04	0
123	circle	900	yes	lateral	0	none	2.83	0
123	circle	900	yes	lateral	5	none	3.1	0
123	circle	900	yes	lateral	6	none	3.07	0
123	circle	900	yes	lateral	8	none	3.95	0
123	circle	900	yes	lateral	10	none	4.28	0
123	circle	900	yes	lateral	12.5	none	4.84	0
124	circle	900	yes	medial	0	none	3.35	0
124	circle	900	yes	medial	5	none	3.43	0
124	circle	900	yes	medial	6	none	3.5	0
124	circle	900	yes	medial	8	none	3.09	0
124	circle	900	yes	medial	10	none	3.54	0
124	circle	900	yes	medial	12.5	none	3.59	0
124	circle	900	yes	lateral	0	none	3.14	0
124	circle	900	yes	lateral	5	none	3.1	0
124	circle	900	yes	lateral	6	none	2.89	0
124	circle	900	yes	lateral	8	none	2.13	0
124	circle	900	yes	lateral	10	none	3.25	0
124	circle	900	yes	lateral	12.5	none	2.99	0
125	circle	900	yes	medial	0	none	5.57	0
125	circle	900	yes	medial	5	none	5.49	0
125	circle	900	yes	medial	6	none	5.61	0
125	circle	900	yes	medial	8	none	5.87	0
125	circle	900	yes	medial	10	none	5.32	0
125	circle	900	yes	medial	12.5	none	4.87	0
125	circle	900	yes	lateral	0	none	3.08	0
125	circle	900	yes	lateral	5	none	2.98	0
125	circle	900	yes	lateral	6	none	2.93	0
125	circle	900	yes	lateral	8	none	2.72	0
125	circle	900	yes	lateral	10	none	2.78	0

125	circle	900	yes	lateral	12.5	none	3.13	0
126	circle	900	yes	medial	0	none	4.15	0
126	circle	900	yes	medial	5	none	3.88	0
126	circle	900	yes	medial	6	none	3.52	0
126	circle	900	yes	medial	8	none	3.88	0
126	circle	900	yes	medial	10	none	4.51	0
126	circle	900	yes	medial	12.5	none	5.2	0
126	circle	900	yes	lateral	0	none	13.62	0
126	circle	900	yes	lateral	5	none	12.11	0
126	circle	900	yes	lateral	6	none	15.7	0
126	circle	900	yes	lateral	8	none	12.11	0
126	circle	900	yes	lateral	10	none	14.22	0
126	circle	900	yes	lateral	12.5	none	16.14	0
127	circle	900	yes	medial	0	none	3.82	0
127	circle	900	yes	medial	5	none	3.85	0
127	circle	900	yes	medial	6	none	3.52	0
127	circle	900	yes	medial	8	none	3.72	0
127	circle	900	yes	medial	10	none	3.42	0
127	circle	900	yes	medial	12.5	none	3.5	0
127	circle	900	yes	lateral	0	none	3.88	0
127	circle	900	yes	lateral	5	none	3.69	0
127	circle	900	yes	lateral	6	none	3.49	0
127	circle	900	yes	lateral	8	none	3.01	0
127	circle	900	yes	lateral	10	none	2.82	0
127	circle	900	yes	lateral	12.5	none	2.68	0
128	circle	900	yes	medial	0	none	2.67	0
128	circle	900	yes	medial	5	none	2.7	0
128	circle	900	yes	medial	6	none	2.54	0
128	circle	900	yes	medial	8	none	2.67	0
128	circle	900	yes	medial	10	none	2.6	0
128	circle	900	yes	medial	12.5	none	2.67	0
128	circle	900	yes	lateral	0	none	3	0
128	circle	900	yes	lateral	5	none	3.16	0
128	circle	900	yes	lateral	6	none	2.7	0
128	circle	900	yes	lateral	8	none	2.95	0
128	circle	900	yes	lateral	10	none	3.22	0
128	circle	900	yes	lateral	12.5	none	2.72	0
129	circle	900	no	medial	0	none	8.49	0
129	circle	900	no	medial	5	none	12.76	0
129	circle	900	no	medial	6	none	12.52	0
129	circle	900	no	medial	8	none	15.46	0

129	circle	900	no	medial	10	none	14.35	0
129	circle	900	no	medial	12.5	none	8.9	0
129	circle	900	no	lateral	0	none	15.88	0
129	circle	900	no	lateral	5	none	16.52	0
129	circle	900	no	lateral	6	none	13.97	0
129	circle	900	no	lateral	8	none	15.43	0
129	circle	900	no	lateral	10	none	9.72	12.92
129	circle	900	no	lateral	12.5	none	9.62	24.23